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OF THE

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BY B. MUSCIO, M.A.

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Among the factors affecting human efficiency in industry, some method of ensuring that so far as practicable every worker shall be placed *ab initio* in an occupation for which he is naturally fitted is perhaps one of the most important.

The high labour turnover commonly occurring amongst beginners employed in factories* tends to show that the initial selection of an occupation is often a matter of chance, and that any permanent employment subsequently obtained is only secured after a process of trial and error. Apart from other considerations, there can be nothing more discouraging than the realisation that a long period of training has only been partly effective and that the time so spent might have been used more profitably in another sphere.

The recognition of these facts has led to the development in recent years of much study of vocational guidance and selection, having for its object the cataloguing of various occupations according to the aptitudes and capacities required in them, and the examination and testing of applicants with a view to advising them as to the occupations for which they are naturally fitted.

It is not, of course, contended that the selection of an occution should depend solely on the application of these methods. Choice is often limited by local circumstances, and in addition there may be other reasons far outweighing any indications derived from vocational tests. Instances, however, must often arise where there is no predisposing tendency towards one of the several available occupations, and it is here where vocational guidance methods are likely to be of greatest value. A boy or girl found to be naturally unsuitable for one occupation, will almost certainly be found suitable for another. Different occupations clearly demand different aptitudes, and vocational guidance as it progresses will merely indicate to the applicant whether one occupation is more suitable in his particular case than another.

In view of the above considerations, the Board have thought that vocational guidance may be regarded as having a direct bearing on human efficiency and fatigue in industry. In particular the degree of fatigue induced by a given task must clearly depend partly on the inherent capacity of the worker to perform that task, and the study of vocational selection was contemplated by the Board on the grounds that it is in its very nature a preventive of fatigue.

As a preliminary step, therefore, they requested Mr. Muscio to prepare a report summarising the whole of the work on the subject. As will be seen from Mr. Muscio's report, most of the research on this subject has been carried out in America, and little attention has hitherto been paid to it elsewhere. A beginning, however, has now been made in this country in the formation of the National Institute of Industrial Psychology, which proposes amongst its other functions to develop vocational guidance on practical lines.

October 1921.

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* *Cf.* Greenwood, M. (1918): The Causes of Wastage of Labour in Munition Factories employing Women.—*Medical Research Council, Report* **16**.

Broughton, Newbold and Allen (1920): A Statistical Study of Labour Turnover in Munition and other Factories.—*Industrial Fatigue Research Board, Report* **13**, p. 16.

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VOCATIONAL GUIDANCE.

(*A Review of the Literature*)

By B. Muscio, M.A.
Investigator to the Board.

SYNOPSIS.

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PART I.—INTRODUCTORY.

(Numbers in square brackets refer to the bibliography.)

Except where it is stated to the contrary, all page numberings given in the text refer to the original papers or books which are being dealt with at the time.

By Vocational Guidance is understood a policy that attempts, on a scientific basis, to guide each individual into an occupation for which his psycho-physiological constitution fits him.

An important distinction has often been made, for example by W. D. Scott [1], between vocational *guidance* and vocational *selection*. The former results from asking: For what occupation is this or that individual best fitted ? The latter results from asking: Is this or that individual fitted for this particular occupation ? The former question places at least as much emphasis on the needs of the individual as on the needs of industry ; the latter emphasises the needs of a particular industry. The former question is the one to which an answer is finally required ; but an adequate answer to it demands extensive investigations. Such an answer, it would appear, will be obtained largely by combining numerous answers to the second question; that is, the growth of vocational *selection* investigations, the results of each of which are unsatisfactory from a final point of view, will slowly lead to a satisfactory vocational *guidance* policy.

The literature on vocational guidance may be divided into two classes, *general* and *technical*. The technical literature, which will be dealt with in Part II, approaches *vocational guidance* almost exclusively by way of *vocational selection*. The general literature, the nature of which will be indicated here, deals (1) with the question of the desirability of a vocational guidance policy, and (2) with the methods to be pursued in determining what are the mental and physiological capacities required for any given occupation.

1. Desirability of Vocational Guidance.

It has been urged in favour of vocational guidance that adaptation of the worker to his work on the basis of natural fitness may be expected—

(*a*) to effect a decrease of industrial fatigue, as the adapted workman's activity follows the " lines of least resistance " ;

(*b*) to bring about an increase in output;

(*c*) to produce a situation in which the worker finds more interest in his work, since unfitness for work normally gives rise to a distaste for it;

(*d*) to reduce labour turnover, as unsuitability of a particular occupation is often given by a workman as a reason for abandoning it; and

(*e*) to reduce the number of industrial accidents, partly by lessening labour turnover and thus decreasing industrial

inexperience upon which industrial accidents to some extent depend [2*], and partly by guiding those who are naturally likely to have accidents [3†] into occupations in which accidents are impossible.

2. Methods in Vocational Investigations.

The currently accepted method for determining the psycho-physiological capacities required in a given occupation is as follows: groups of persons engaged in the occupation and representing different grades of efficiency are given a number of tests and the test results are compared with work records by the method of correlation. The degree of similarity between the two is expressed in *correlation coefficients*: numbers ranging from + 1 to — 1, usually indicated by the letter *r* or R.§ The closer a correlation coefficient approaches to + 1, the greater is the degree of correspondence between the two series that are being compared. If the results of a certain test were to give a correlation coefficient of + 1 with actual efficiency in an occupation, that would mean that the grading of the persons for efficiency in their work was identical with their grading for efficiency in the test. The size of the correlation coefficient of efficiency in an occupation with efficiency in any given test may be taken to indicate how far the capacity tested by the test is required in that occupation. Probably the chief difficulty to be overcome in carrying out this procedure is that of obtaining a reliable efficiency grading for the occupation.

The choice of the tests to be used in any given case has been guided by a variety of considerations. H. L. Hollingworth [4] distinguished four different procedures by which the desired information might be obtained: a broadly similar classification has recently been described by C. Burt [5].

(*a*) The experimenter may use "sample tests": that is, standardised samples of the actual work may be used as tests.

(*b*) Or he may use "analogous tests": here the test is no part of the actual work but is modelled on it and is similar to it—perhaps is a miniature of it.

(*c*) The experimenter may first observe the occupation and analyse it into its psycho-physiological or neuro-muscular elements, and then give standard tests for each of these elements.

(*d*) Or finally, a very empirical method may be used: the experimenter may give a number of tests chosen at random and simply accept as good tests those that yield large correlation coefficients with efficiency in the occupation.

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* See bibliography, Goldmark and Hopkinson.

† See bibliography, Greenwood and Woods.

§ *r* indicates a coefficient obtained by the "product moment" formula, R a coefficient obtained by the "footrule" formula (*cf.* text-books on statistics). In this report coefficients are given as *r*'s or as R's according to the formula used by a particular investigator.

In practice, this fourth procedure is usually more or less similar to the third, since practical reasons always demand some limitation of the number of tests used. An extreme form of this fourth method consists of an exhaustive psycho-physiological examination of a few of those persons who are found to excel in a given occupation. The earliest methodical attempts to determine vocational aptitudes followed this procedure. Thus, E. Toulouse endeavoured to make such an examination of the French mathematician, Henri Poincaré [6], of the novelist Zola, and several other noted persons. A critical account of this work is given by H. L. Hollingworth [7]. This procedure has never been used in industry.

It has sometimes been urged that vocational aptitudes are determined not so much by the possession or lack of special mental or physiological capacities as by general emotional and temperamental qualities. In the pioneer work of F. Parsons [8] much stress is laid upon these qualities, though their treatment is quite unsatisfactory from a scientific point of view. H. Schneider [9] maintains that the difference between the person who likes monotony and the person who likes variety is of the greatest industrial importance, and he advocates the classification of occupations by reference to such general qualities as these. A few attempts have been made to determine whether *interests* could be made the basis of vocational guidance. E. L. Thorndike [10] found a high degree of correspondence between *interests* and *abilities* among college students when the students ranked the subjects of their curriculum on the basis of their *interest* in each and when they themselves estimated their relative *ability* in each. Bridges and Dollinger [11], however, compared the relative *interests* of several hundred students, determined by themselves, with their relative *abilities* as *determined by college success.* The degree of correspondence was found to be almost negligible, the authors concluding, in direct opposition to Thorndike that " a person's relative interests are an extraordinarily *in*accurate symptom of his relative capacities." H. D. Kitson [12] gives various reasons against the idea of basing vocational guidance on interests. There is the difficulty of estimating the intensity of an interest, the psychological fact of competing interests, the relatively fleeting character of many interests, and the fact that many occupations excite little or no interest. When it is added that the relation of interest to capacity is ambiguous, and that a youth's interests are often a consequence of insufficient knowledge about occupations, it seems clear that little use can be made of interest by vocational guidance. It is generally recognised, however, that temperamental factors are very important, and their relation to different occupations is urgently in need of investigation.

Concerning the tests used in vocational guidance investigations, these have been mostly the psychological tests given in standard text-books, or modifications of these tests. Of such books, G. M. Whipple's *Manual of Mental and Physical Tests* [13]

is the most valuable at the present time, though many of the tests described in it require to be modified if they are to be used for industrial purposes. *Measure Your Mind* [**14**] by Trabue and Stockbridge, is a practical book, and gives a number of "intelligence tests" which may be used, in appropriate conditions, with little or no modification. The tests are of unequal value.

PART II.—SUMMARY OF SPECIAL INVESTIGATIONS.

1. Clerical Occupations.

Considerable attention has been given to clerical occupations, and interesting results have been obtained. In addition to published investigations, there have been others that have not been published, these latter having been made at the expense of firms who considered the results of sufficient value to be kept secret. Thus Prof. E. L. Thorndike devised a set of tests for the Metropolitan Life Insurance Co., New York, and these the firm continues to use with satisfactory results; but the tests themselves have never been published. The published investigations have gone a measurable distance towards defining the requirements for office workers, and in standardising tests for the detection of the presence or absence of the required capacities. Broadly, these investigations suggest that *general* clerical work requires a certain level of intelligence (which, however, has yet to be allotted a place in the scale of intelligence levels for different occupations), while *specialised* office work (such as typewriting, stenography, and computing machine operating), requires in addition certain special capacities, such as a relatively large immediate memory span.

A. *General.*

W. F. Kemble [**15**] gives a number of tests for which he claims that they will "not only pick out the man of great capacity from among any mixed company undergoing the test, but will arrange a staff of men in the approximate position of their ability when certain weights are assigned according to the nature of the work" (pp. 19–20). The tests are intended for the selection of "executives" and "semi-executives." Evidence of their value is not given. They aim at the measurement of association-time ("thought speed"), writing speed, mathematical speed (addition), ability to withstand interruption, "concentration," memory for faces, observation, general information, ability to interpret and follow complicated instructions, and so on. The tests are suggestive and sometimes ingenious; but tests for the capacities concerned have already been standardised. The *directions* test (p. 40) should be specially noted. The material for this is a

square divided into 169 smaller squares by intersecting lines drawn parallel to its sides. The test consists in making marks in various specified small squares according to directions which begin : " black in the little squares on each side of each corner by making cross marking with the pencil." The association-time tests (controlled association) are put in an interesting form (pp. 21–25).

S. Cody [**16**] describes in detail the present form of the " National Business Ability Tests," their history, the procedure to be adopted in giving and the methods of scoring them. They were devised by a U.S. National Committee consisting partly of educationists but chiefly of business men, which is now the " Business Standards Association." The tests are based upon the principle that " the proper vocational equipment for three fourths of all commercial employees is accuracy and speed in handling figures, and correctness in spelling, punctuating, and reproducing instructions, and composing letters " (p. 6). They therefore aim at the measurement of attainments and not of native ability, except in so far as this is expressed by attainments. Much care has clearly been taken in constructing them, and for their purpose they seem extraordinarily good. Only a few are of psychological interest. The first of these is a general intelligence test, which consists in analysing a table so as to extract from it certain specified information of a somewhat complicated nature (pp. 57–63). The second is a logical memory test. Five minutes are allowed to memorise instructions for filling up a sales slip assuming certain conditions of sale, and ten minutes for reproduction in writing (pp. 63–69). The third is a general intelligence test of the type called *directions* test. This consists in filling up a sales slip from certain directions (pp. 70–86). The remaining tests—for fundamental arithmetical operations, percentages and fractions, spelling, punctuation, grammar, composition, stenography, typing, and so on—are almost altogether tests of *acquired knowledge*, of " intelligence under the domination of habit " (p. 31). Scores obtained in the tests by American employees of different clerical grades are given here and there throughout the text, and in an appendix a number of results obtained from American school children of the higher grades.

The author advocates the use of the tests in schools. He thinks there is frequently too much hurry in an employment office for a proper giving of tests, and that business men could obtain greatest value from them if allowed simply to inspect the record of an applicant's performance in them when at school. He has found it practicable to allow school teachers to give the tests and the children to mark them, care being taken that they are suitably checked.

While no precise results are given, the value and relevance of the tests were tested by giving them to numbers of clerical employees in various business houses. They were given, for instance, to employees of the National Cloak and Suit Co., The

National Cash Register Co., The Borroughs Adding Machine Co., The Commonwealth Edison Co., Marshall Field & Co. and Swift & Co. Partly as a result of these investigations, the tests have developed into their present form. The program of the " Business Standards Association " includes the construction of other tests in principle the same as the above, but differing from them in test material. This is to prevent the tests being " got up " by those taking them.

Non-adaptation to work due to lack of the *knowledge* required for it must cause unnecessary fatigue; and consequently tests of attainments are relevant to any attempt to decrease industrial fatigue.

J. Dück [**17**] advocates tests involving *rapid visual comprehension* and *immediate memory for the spelling and construction of words*, as valuable in the selection of all kinds of clerical workers. He gave a series of six tests, gradually increasing in difficulty, each consisting essentially in the finding of specified names or words in directories or dictionaries, to a fairly large group of clerical workers of various grades. Details of the results are given (pp. 14–23) together with information concerning the education, clerical status and experience of the subjects, and finally the judgments in many instances of their employers as to their efficiency in their particular clerical work. The ages of the subjects varied considerably, but many were under twenty. The author states that the test results corresponded well with practical efficiency; but correlation coefficients were not obtained, and conclusions are difficult to draw from his tables of results without considerable analysis. At the same time, the nature of general clerical work suggests that he is right in emphasising the importance for clerical workers of the mental functions which his tests were designed to measure; and these tests, or others of the same type, would probably be included among tests for such workers with advantage.

It was found incidentally that the test performances of the women subjects were definitely poorer than those of the men, and as regards both education and practical experience neither sex was thought to have had any advantage over the other (p. 11); an important result, if it should be confirmed.

In an interesting appendix (p. 24), S. v. Máday emphasises the importance of the *capacity for mental analysis* in all clerical work; as indicated especially in the work of finding suitable headings for filing more or less complex material. An outline of a topical filing test, devised by R. Jokl, is given. H. C. Link [**18**] found such tests of value in selecting *filing* clerks; but as indicative of the capacity for clear thinking, or theoretical analysis, they would probably possess significance for clerical workers in general.

H. C. Link [**19**] gave tests to fifty-two men and women engaged on different types of clerical work. The tests were intended to measure both *technique* and *intelligence*. Those for technique were the following four :—

(*a*) a *motor steadiness* test (passing a metal rod between two brass bars which gradually approached one another, without allowing it to touch the bars);

(*b*) a *simple calculation* test (simple arithmetic—addition, multiplication, &c.);

(*c*) a *card sorting* test (sorting cards, from a pack of fifty, into three piles, according to certain directions);

(*d*) a *substitution* test (substituting certain *letters* for other letters according to a key).

Two tests were given for the purpose of indicating differences in intelligence :—

(*e*) the Woodworth and Wells *Hard Directions* test [**20**];

(*f*) a *mixed relations* or *analogies* test [**21**].

The group of fifty-two clerks fell into four smaller groups on account of the fact that they were doing different types of work : a time-study group, a ledger group, a statistical group, and a computing machine and sorting group. A comparison of the test results with the efficiency of the clerks in their work " showed a very marked agreement between the testimony of the tests and the rankings of the office manager " (p. 80). The tests separated the four groups very much according to the relative values of their work. The results for certain specified individuals showed a very distinct agreement between the test performances and the judgment of the management. Correlation coefficients are not given, except one of $+\cdot 55$ for *technique* with *intelligence*.

On the basis of the results obtained, these tests were given to all new clerks as a method of selecting those suitable for the work. The selected individuals were subjected to a follow-up system, so that information might be acquired as to the value of the tests and the necessity for any possible modification or extension of them. The results are not given in detail; but it is said that they " showed very clearly that the tests were an aid in the selection of clerks " (p. 84). For instance, of one hundred and eighty-eight clerks recommended on the test results and " followed up " at intervals of one month for a period of three months, 75 per cent. were judged to be *good* by their overseers at the end of *one* month, 89 per cent. at the end of *two* months, and 92 per cent. at the end of *three* months (p. 87). The tests had been given to nine hundred and thirty clerks who had been accepted on the results; but details concerning the majority of these are not given. The manager of the office stated after the tests had been given to the first fifty-two clerks : " The tests which have been employed in this office seem to supply the mechanical means of quickly and cheaply determining to a practical degree the manual, ocular, and mental technique demanded for certain classes of routine office work " (p. 78). The results reported for several individual cases also suggest the value of the tests. Difficulties in obtaining reliable ratings for efficiency from overseers are discussed (pp. 84–86).

L. L. Thurstone [22] considers that no *special* abilities are required for clerical work (at least, of the lower grades), but that the important factor involved is a certain level of intelligence; acceptable candidates for office work should reach some specified minimum intelligence standard. He devised a set of eight tests consisting essentially in samples of clerical work and these seem to have been carefully standardised. The tests are as follows :—

(*a*) checking errors in addition and subtraction;

(*b*) checking errors in spelling in a text chosen so as to catch the subject's interest, thus producing a distraction from the task, of the kind that occurs frequently;

(*c*) cancellation of specified letters;

(*d*) a substitution test;

(*e*) an alphabetising test, in which the subject places each of forty names in one of ten compartments according to directions and alphabetises the names in each compartment;

(*f*) analysing a table of complex matter to extract from it certain specified information;

(*g*) a simple arithmetic test;

(*h*) an "intelligence" test (matching proverbs).

The tests were given to one hundred employees of a large insurance company ranging from minor executives to clerks on routine work. They were divided into five classes according to the grade of office work on which they were engaged. The following correlation coefficients were obtained :—

Accuracy in the test and clerical grade, $r = +\cdot 50$
Speed ,, ,, ,, $r = +\cdot 42$

It was found that amount of schooling correlated with office grade $+\cdot 47$, while age correlated with office grade $+\cdot 35$.

Combining the results in various ways gave the following coefficients :—

Accuracy and speed combined, with clerical grade, $r = +\cdot 61$
Schooling and age ,, ,, ,, $r = +\cdot 52$
Accuracy, speed, schooling ,, ,, ,, $r = +\cdot 64$
Accuracy, speed, schooling and age ,, $r = +\cdot 67$

It thus seems that this set of tests would be a useful addition to the present methods of determining fitness for clerical occupations. A few other tests, however, might with advantage be included also; for example, a topical filing test, and a test consisting of the finding of items in directories or dictionaries, as advocated by Dück (above).

The set of eight tests require about forty-five minutes. The author urges the importance of tests occupying a fair amount of time, as he considers that such tests yield much more reliable information than "ten-minute" tests. No doubt if an applicant for a clerical post were given carefully arranged samples of clerical work to do for an hour, it would be possible to tell, first if he was fitted or unfitted for clerical work, and secondly (if

he were fitted for it) for what type of clerical work he was best fitted, more satisfactorily than if a much shorter test were used.

B. *Typewriting.*

J.-M. Lahy [**23**] presents briefly the results of an investigation (carried out in 1905) to determine the psycho-physiological requisites for a good typist. A number of tests were given to eleven subjects, of whom six were women who had had from two to four years' typewriting experience and five men of from two to eight years' experience. The ages of the subjects fell between twenty and thirty. The capacities tested were the following :—

(*a*) sustained attention (by a cancellation test);
(*b*) touch sensibility;
(*c*) muscular sensibility (determined by the myo-aesthesiometer—weight lifting);
(*d*) auditory reaction-time (with a d'Arsonval chronometer);
(*e*) muscular symmetry of the two hands (by means of a dynamometer); and
(*f*) immediate memory span (for digits and concrete phrases).

Some tests for higher mental functions (abstraction and reasoning) were also given, but they yielded no positive results and it is not said exactly what they were. Indeed, none of the tests is adequately described, and nothing is said as to the procedure adopted in giving them.

The correlation method of determining the relevance of the capacities tested to typewriting is not used, except in a very rough way : namely, the results for typists who are designated *good* are compared with those who are designated *bad*. The distinction between the good and bad typists was based upon the results of a typewriting test which consisted in the copying of a short piece of connected prose. The quickest typist carried out this test in 3′ 25″, the slowest in 11′ 20″. The results were judged by a director of a typewriting office and by several typists not taking part in the investigation. The basis of the judgments were speed, quality (errors), and " arrangement."

The results for the men and women are presented separately in two tables from which the author concludes that a good immediate memory for concrete phrases, a tendency to muscular equivalence in the strength of the two hands, a fine tactile and muscular sensibility, and a capacity for sustained attention are the psycho-physiological requisites for a good typist (p. 833). He considers that these should *all* be possessed by the good typist, and not merely one or several of them ; but he also thinks that long practice may in isolated cases produce reasonable efficiency even if these capacities are not all present, and one case of this sort is given.

As the actual performances of all the subjects in most of the tests, including the typewriting test, are given, we are able to calculate the correlation coefficient of each test with typewriting efficiency (as determined by the typewriting test). These coefficients are here given as they allow a better estimation of the author's conclusions. They are as follows :—

*Immediate memory for concrete phrases -	$r = +\cdot 60$
Immediate memory for digits - - -	$r = +\cdot 27$
*Muscular symmetry (tendency of the two hands to be identical in strength) -	$r = +\cdot 68$
*Tactile sensibility - - - - -	$r = +\cdot 77$
*Muscular sensibility - - - -	$r = +\cdot 58$
Sustained attention (judged by errors in the cancellation test) - - - -	$r = +\cdot 18$
Sustained attention (judged by time taken in the cancellation test) - -	$r = +\cdot 14$
Auditory reaction-time - - - -	$r = -\cdot 34$

Lahy's conclusions from his tables are thus seen to be largely correct. He was wrong, however, in supposing he could infer that sustained attention, as measured by his cancellation test, is required by a typist, as the coefficient of this test and typewriting is non-significant. The relevant capacities thus appear to be those marked with an asterisk. If we combine the results of these four tests (by averaging the ranks of the subjects in each of them), the resulting ranking yields with typewriting efficiency a correlation coefficient of $+\cdot 89$. This is a distinctly high coefficient. Further investigations should be made with Lahy's tests for the purpose of verifying this result. Various reasons make this desirable; for instance, tactile and muscular sensibility are difficult to test, and Lahy does not even say on what part of the body the tactile sensibility was determined. The number of the subjects, also, was too small to give a convincing result.

J. E. Lough [**24**] gives a short account of some experiments yielding significant correlations between typewriting and " business forms " (including stenography), and performance in a substitution test. The test consisted in substituting letters for letters (an A for an F, a B for a G, etc.) according to a key or code, and merit was determined, not by a single performance of the test, but by ability to improve in a number of performances. The subjects, apparently boys, were pupils in New York High Schools, studying commercial as well as other subjects. Their relative capacities for (i) typewriting and (ii) " business forms " (including stenography) were gauged by their teachers, whose ranking for these subjects was compared with the experimenter's ranking for capacity in the substitution test. The author does not say how many subjects took the tests, although he considered the number adequate to yield a reliable result. His correlation curves suggest that he had very few—six only in typewriting and nine only in " business forms "—and these seem to have been beginners. It is doubtful how far the teachers' ranking in typewriting and " business forms " indicated special ability for

these subjects and how far general ability to learn. The substitution test, as used, was a learning test, and thus might give a high correlation with learning in other subjects without yielding any indication of specific natural capacity for these other subjects. No correlation coefficients are given; but if the correlation curves are rightly interpreted to mean that the groups consisted of six subjects in typewriting and nine in business forms, it is possible to calculate the coefficients from these curves. These are +·92 (*p.e.* =·04) between the test and typewriting, and +·75 (*p.e.* =·10) between the test and "business forms." As the author obtained significant (though lower) correlations between the test and (i) German and (ii) Mathematics also, the idea is strengthened that the test indicated chiefly a general ability to learn. The results are presented with insufficient detail and the paper is suggestive only.

H. W. Rogers [**25**] gave ten tests to forty-five students (forty-three young women and two men) of typewriting and stenography (ten hours class study in each per week) in the Columbia University Extension Department. The ages of the subjects ranged from sixteen to thirty-eight. Nine of the tests were taken from the Woodworth and Wells series [**26**]. These were: opposites, verb-object, agent-action, action-agent, colour naming, mixed relations, hard directions, number group checking, and form substitution. The tenth was a Trabue* language test. This, together with the number group checking and substitution tests, was given to all the subjects together, while the remaining tests were given individually. In the form substitution, directions and number group checking tests no account was taken of errors: it is not said how the performances of the remaining tests were scored. Once a month the subjects were given a *typewriting* test consisting of writing from dictation for ten minutes (five words were deducted for each error, and the performance was then expressed as the number of words typed per minute). The results for the psychological tests were correlated with the results for each of six such typewriting examinations. In *stenography*, a half-yearly examination was given, and the subjects were graded for stenographic capacity by the results of one such examination (presumably after the subjects had been working at stenography for six months).

The coefficients obtained with certain of the tests and *typewriting* varied considerably in size from month to month. Several of them correlate fairly highly (a complete table of all the monthly coefficients is given, p. 272). Opposites, directions and form substitution combined give a coefficient of +·63 with stenography, while verb-object, colour naming and number group checking give a coefficient of +·63 with typewriting. Other combinations of tests yield lower coefficients. The results seem to indicate that *rapidity in the reproduction of acquired associations* is important for both stenography and typing.

* *Cf.* the note to p. 16.

H. C. Link [**27**] gives a general account of attempts to obtain satisfactory tests for typists. A number of apparently relevant tests was given to a group of twenty-two office typists and to over four hundred candidates for position as typists and stenographers (p. 88). Detailed results are not given, but it is said that the following four tests proved themselves useful practical guides in selecting typists :—

(*a*) an *actual typing* test;
(*b*) a *spelling* test;
(*c*) a *substitution* test;
(*d*) a Trabue *completion* test.*

Examples of the tests used are given. It will be observed that (*a*) and (*b*) are tests of *acquired* skill and knowledge. For beginners (*a*) could not be used. No test was given for *manual dexterity* or *immediate memory span.*

Link [**28**] also describes briefly extensive experiments to obtain selection tests for stenographers. No details are given of the results, but the following four tests are indicated as practically useful for this purpose :—

(*a*) a Trabue *completion* test
(*b*) a *grammar* test (correcting errors in grammar);
(*c*) a *spelling* test;
(*d*) a *dictation and transcription* test.

These are, with the exception of the first, tests of *acquired* knowledge and skill. Examples of the tests used are given (pp. 393-435).

J. C. Chapman [**29**] in a study of progress in learning typewriting, found that actual typewriting efficiency at the end of twenty hours of practice correlated $+\cdot 65$ with efficiency at the end of 140 hours' practice. He considers that a mental test occupying fifteen minutes would be a better selection test for typists than twenty hours' typewriting practice (p. 267). There were twenty subjects (ages 16–18).

C. *Computing Machine Operating.*

H. C. Link [**30**] gives a short account of experiments aiming to determine tests for selecting computing-machine operators. Detailed results are not given, but it is said that the following three tests were found practically useful for this purpose :—

(*a*) a *mental arithmetic* test;
(*b*) a test in *comptometry* itself;
(*c*) a *substitution* test (digits for digits).

Tests (*a*) and (*b*) are largely tests of *acquired* knowledge and skill. Test (*c*), given to subjects not expert as operators, was

* *Cf.* M. R. Trabue's *Key for Completion-Test Language Scales* (published by Teachers College, Columbia University, N.Y., 1919). This contains a number of language completion tests and gives detailed instructions for scoring, &c.

found "to correlate very well" with their subsequent ability (p. 98),though coefficients are not given. General intelligence tests were not found to correlate significantly with operating efficiency (p. 98).

L. Marcus [**31**] describes an investigation made to determine the capacities required by Hollerith card-punchers. A set of nine tests, most of them taken from the Woodworth and Wells series of association tests was given to over one hundred persons engaged on this work, and the correlation coefficients of each test with efficiency in the work was calculated. These coefficients were all low, though positive; only three tests yielded *significant* coefficients. These were (p. 200.) :—

(i) *Substitution*—numbers for geometrical forms—($r = +\cdot 236$; *p.e.* $= \cdot 055$);

(ii) *Completion*—filling up a mutilated text—($r = +\cdot 211$; *p.e.* $= \cdot 054$); and

(iii) *Logical sequence*—arranging disarranged sentences in logical order—($r = +\cdot 316$; *p.e.* $= \cdot 051$).

By combining these tests (by averaging the ranks) an $r = +\cdot 453$ (*p.e.* $= \cdot 045$) was obtained. This is *contrasted* with the smallness of the correlation of efficiency in the work and in the civil service examination (on the results of which engagement for the work depended), this correlation being $+\cdot 31$ only (*p.e.* $= \cdot 06$). The civil service examination (consisting of spelling, arithmetic, letter writing, penmanship and copying) is said to require several hours to give and at least ten minutes to mark, while the three above-mentioned tests can be given in less than ten minutes and marked in less than two. (It is shown incidentally that a higher correlation is obtained by taking each of the five civil service subjects as of equal value than by weighting them by the civil service method). The author, however, somewhat over-emphasises the value of his results, for, after all, the correlations he obtained were not pronounced, and very probably more suitable tests would give larger coefficients. The prevalence of statements unsupported by correlation evidence about the value of this or that test for selecting for this or that type of work, is justly criticised; but the author forgot that he had said, in the beginning of his paper, that "Rapid co-ordination of eye and finger is the main requirement of a good worker" (Hollerith card-puncher), since among the tests he used there is not one which even attempts to test this capacity, while two of the three tests that yielded significant positive coefficients are tests of "intelligence." The paper has other defects also. In particular, it should have been stated why the numbers of subjects were not the same for all the tests (*see* table on p. 200) : why, for instance, there were 133 for the *directions* test and 138 for the *logical sequence* test. On p. 198 it is said that "the tests were administered to two groups of about 75 in each group"—which gives "about" 150. The investigation suggests that general intelligence is *one* factor in the efficiency of the Hollerith card-puncher.

Hollingworth and Poffenberger [**32**] give correlation coefficients of certain tests with (*a*) "clerical workers," (*b*) minor executives, and (*c*) "correspondents." The tests were all either tests of intelligence or of speed of reproduction of associations. The experiments yielding the results have not been published.

2. Engineering and Metallurgical Occupations.

A number of selection investigations has been made relating to a considerable variety of occupations connected with engineering work. Tests have been proposed for (1) routine work, such as gauging and dial machine operating, (2) general engineering ability as required by an apprentice, (3) professional engineering ability. In some cases, the tests have been based upon *an analysis* of the type of work concerned, from the point of view of the capacities required for it. The results have been such as to justify a more thoroughgoing attack on the general problem of diagnosing "engineering" ability than has yet been made. While intelligence, as is to be expected, appears to be the important factor in professional engineering ability, the more or less routine work of the various occupations in metal-working shops seems to demand special abilities, though a certain intelligence level doubtless needs to be presupposed.

A. *Heavy Muscular Work.**

F. W. Taylor [**33**] made an empirical selection of workmen or the lifting and carrying of pig-iron. No strength or endurance tests were given, but a certain standard of work was set as a day's "task" and only those men who could attain it were employed. A thorough re-organisation of the work was made simultaneously, based upon time and motion studies, and probably much of the extraordinary result achieved was due to factors other than selection of workmen (the men finally handled about forty-eight tons of pig-iron individually per day). That selection nevertheless played a considerable part in this result may be inferred from the fact that, of the original group of seventy-five men who were employed on the work when Taylor began to reorganise it, only one in eight (in Taylor's *Shop Management*, p. 55, this is given as one in five) was found physically capable of the set task (p. 61). That *mere* physical strength was not the sole requirement for the work may be inferred from the fact that one of the men who made the daily task for a period of several years was a small man (p. 43) who weighed about one hundred and thirty lbs. only (see *Shop Management*, p. 50, 1911 edition). *Mental* characteristics are stressed: "one of the very first requirements for a man who is fit to handle pig-iron as a regular occupation is that he shall be so stupid and so phlegmatic that he more nearly resembles the ox in his mental

* "Heavy muscular work" of course occurs in numerous industries, and not merely in the metal trades. It is discussed here, however, because the illustration given is taken from the writings of an engineer, and concerns work that was carried out in a metallurgical plant.

make-up than any other type" (Taylor's *Principles*, p. 59). Of course, so long as this type exists, physical labour is the only kind of labour on which it can be employed; but education should make it less common and the application of power machinery should decrease the need for it. Taylor's selection is, in any case, of little general value because it was altogether empirical, and, beyond giving a few suggestions, it indicated no scientific method* by which men suitable for heavy work can be selected. It is useful as emphasising the fact that those engaged in certain occupations, not all of which are unskilled, should possess physical strength in a relatively high degree.

B. *Inspecting.*

In 1911,† F. W. Taylor [**34**] gave a short description of a selection of girls for the work of bicycle-ball inspecting, this selection being carried out under his direction in the plant of the Symonds Rolling Machine Co., Fitchbourg, Mass., by S. E. Thompson. The work consisted in placing a number of balls in the crease between two fingers of the left hand turned palm downwards and picking off with a magnet defective balls while they were being examined in a strong light. Four kinds of defects had to be watched for—dents, softness, scratches, and fire-cracks. According to the account of the selection given in *The Principles of Scientific Management* (1911), one is led to infer that the girls were given a reaction-time test and that only those who showed a quick reaction-time were engaged for this work. The case is there given *to illustrate the principle* that in certain conditions "scientific selection of the workmen counts for more than anything else" (p. 86). Some of the girls already engaged as inspectors were found to show a long reaction-time and were dismissed, although this involved the dismissal of "many of the most intelligent, hardest working, and trustworthy girls" (pp. 89–90). The broad result was that after selection thirty-five girls did, in a shorter working day, as much work as one hundred and twenty had done before selection.

The fact is, however, that the test used was made with a stop-watch, and therefore was not a "reaction-time" test. The girls were timed in the performance of *certain elements of the work*, and those who could carry out these elements relatively rapidly were engaged; *provided that they were industrious.* The large increase in individual output cannot be attributed to selection alone, since "scientific management" generally was introduced along with selection. Other innovations, which are given with more completeness in *Shop Management* [**35**], included seating the girls so far apart that they could not talk, shortening the working day, and substituting a differential piece-rate for a

* An investigation into the measurement of physical strength with reference to vocational guidance has recently been made for the Board by the writer, and will be published in Report No. 16, "Three Studies in Vocational Selection."

† This case was first described in 1903. *See* p. 52, *below*.

flat day rate.* Hence, it is not possible to determine how much of the results was due to selection.

About fifteen years after Taylor's bicycle-ball case was first published, H. C. Link [**36**] described in some detail an attempt to select girls for shell inspecting in a small-arms factory. Before the shells were loaded they were inspected for dents, scratches, stains, and other minute defects. During this process the girl would turn the shells over in various ways, throw out the defectives and place the perfect shells in an appropriate box. An observational analysis of this work suggested that the capacities required for it were the following five :—

(1) good eyesight (the defects in the shells were often very minute);

(2) keen visual discrimination;

(3) quick reaction-time;

(4) accuracy of movement (required in picking the right shell from a closely-held handful);

(5) steadiness of attention (the least wavering of the attention seemed likely to allow some bad shells to be missed).

A set of seven tests was selected for testing these capacities; and the aim of the experiment made with them was to determine their suitability as selection tests for the work of inspection.

The method used was to obtain correlation coefficients of efficiency in inspecting and efficiency in the tests. Fifty-two inspectors whose work capacity was known were given the following tests, and the following correlation coefficients with actual working efficiency were obtained (in obtaining the ranking for inspecting efficiency, one month's work was made the basis of calculation) :—

Test.	Correlation Coefficient.
(*a*) Card sorting	R = +·56
(*b*) Tapping	R = +·14
(*c*) Cancellation	R = +·63
(*d*) Easy directions	R = +·14
(*e*) Number group checking	R = +·72
(*f*) Accuracy of movement	R = +·38
(*g*) Steadiness of movement	R = +·24

Description of the tests.—(*a*) A pack of forty-nine cards, upon the face of each of which were from seven to twelve letters, had to be sorted rapidly into two piles, one of which was to contain all cards with the letter O on them, while the other was to contain the remainder. The score was the time taken corrected for errors.

(*b*) The subject was required to depress the key of a Veeder counter as many times as possible in one minute. The score was the number of "taps."

* As this case has been much quoted, a fuller analysis of it is given in an appendix (*see below*, p. 52).

(*c*) The Woodworth and Wells *cancellation* test [**37**].

(*d*) The Woodworth and Wells *easy directions* test [**38**].

(*e*) The Woodworth and Wells *number group checking* test [**39**].

(*f*) A modification of the Whipple steadiness test [**40**]. The task was to insert a metal rod into circular holes in a brass plate without allowing it to touch the circumference. The holes formed a series graduated in size. Contacts were electrically recorded. Each girl was allowed fifteen trials, and the average of the last ten constituted her test performance. In any trial, the score was the hole in the series at which the metal rod had made contact with the circumference of the hole.

(*g*) The task here consisted in having to pass a metal rod between two brass bars inclined towards each other at one end, without touching either. The subject began at the end where the bars were widest apart. Contacts were electrically recorded. Each subject was given fifteen trials, and the average of the last ten constituted her score in the test.

In addition to shell inspecting, there was in the works a large amount of inspecting differing from shell inspecting only in the material inspected. The three tests giving the largest coefficients with efficiency in shell inspecting were tried on representative groups of inspectors of other kinds of work, namely, on twenty-eight *cartridge* inspectors, on thirty *paper shot shell* inspectors, and on ten *bullet* inspectors. The coefficients for the *cartridge* and *bullet* inspection were almost as high as for the original shell inspection; but those for the *paper shot shell* inspection were *all* insignificant. This is explained by the fact that this group of thirty paper shot shell inspectors was very homogeneous, the average difference in the rates of production between the girls being only 2·2 per cent. Homogeneity of a group lowers correlation coefficients, and in these groups of inspectors the size of the coefficients decreases with decrease in heterogeneity (as determined by individual differences in output). The insignificant coefficients obtained with the *paper shot shell* inspectors should not therefore be taken to invalidate the general conclusion of the investigation, particularly as significant coefficients were obtained with each of the other three groups.

Hence, three tests, *card sorting*, *cancellation*, and *number group checking* gave significant positive coefficients with the work of inspecting. The value of these tests for selection may be judged from the fact that when the fifty-two girls were divided into two groups, the piece-workers and the day workers—the latter being those who could not produce enough to earn a living on piece-work—the piece-workers were at the top in the tests and the day workers at the bottom. This arrangement of results yielded a standard of performance in the tests which should prevent the engagement of such girls as could not become piece-workers. The coefficients obtained with the remaining four tests were too low to justify their use in selection (with the possible exception of accuracy of movement). The investigation showed the importance of eyesight, though from the nature of the case no coefficients could be calculated here.

It is important to observe that the three tests yielding significant positive coefficients are all essentially similar. Rapidity of observation is involved in all of them; so is "steadiness of attention"; the card-sorting test requires in addition a certain manipulative capacity. The tests were later given to some thousands of inspectors, and their suggested utility was confirmed. For instance, regarding ninety-four girls who had been given the tests and employment afterwards, the average length of service of those who had been recommended on the test results was 9·56 weeks, while that of those not recommended but nevertheless engaged was 1·05 weeks only.

C. *Gauging.*

The set of tests given by Link to the inspectors was given by him to twenty-one gaugers also [**41**].

In gauging, the operator picked up a number of shells, and, with or without looking, tried the head of each on a gauge—a piece of steel with two openings in it. The shells which were too *small* passed through the first opening and fell into a box for defectives. The remainder were tried in the second opening and were the right size when they passed through it. Failing to pass through, they were rejected as too *large*. The coefficients for *five* of the seven tests and efficiency in gauging are as follows (those for the remaining two are not given) :—

Test.	Correlation Coefficients.
(*a*) Card sorting - - - - -	R = +·05
(*b*) Tapping - - - - -	R = +·52
(*c*) Cancellation - - - - -	R = +·17
(*d*) Easy directions - - - -	R = +·18
(*e*) Number group checking - - -	R = −·19

The only test that yields a significant positive coefficient is (*b*) *Tapping*. Consequently, this is the only test, among the set used, that could be employed for selection. It is particularly interesting that the tests yielding significant positive coefficients with inspection, yield here non-significant coefficients (tests *a*, *c*, and *e*), and vice versa (with the exception of *d*, which yields a small positive *r* in both cases). Link thinks the result for tapping here is what might be expected, as *speed of movement* and *endurance* seem the chief capacities required in gauging.

D. *Assembling.*

Link [**42**] further describes an attempt to select girls and men for the work of assembling small gun parts. This work consisted in placing the parts in their proper positions and then hammering, screwing, pushing, or springing them together. The tests used for selection were the following :—

(*a*) *a form-board test* (the subjects were required to put back into their appropriate holes blocks of different sizes and shapes which had been cut out of a board);

(*b*) *a second form-board*, specially devised to test *form perception* (*a* was devised chiefly to test *manual dexterity*);
(*c*) a *strength of grip test* (three trials with each hand).

These three tests were chosen as a result of observational analysis of the work of assembling. Eighteen girls were tested by them, and twelve were engaged on the results, though an arbitrary standard had to be set as to what constituted a bad performance. As these girls were assigned to rather different types of assembling, it was impossible to get a *production* ranking for them; but after a period of from one to two months a ranking was obtained from their foreman and section head as to their relative efficiency at the work. A close correspondence was shown between this ranking and the rankings in the tests, as is indicated by the following correlation coefficients :—

(*a*) Form board (manual dexterity)	R = +·52
(*b*) ,, (form perception)	R = +·72
(*c*) Strength of grip - - - -	R = +·34

The supervisor of the assembling shops wrote as follows concerning the results : " The tests . . . for assembling have proved beneficial and I would like to see them . . . extended to men applicants. We have had only two failures so far out of twelve new girls, and the tests given these (two) girls showed that they (the girls) were slow to begin with." It should be noted, however, that the number tested was small, and results not altogether confirmatory of those here given were obtained in later experiments on men. In these Link tested altogether one hundred and eight men assemblers, fifty-seven " action " and fifty-one " finishing " assemblers. The work of these men was more complex and required greater skill than that of the girl assemblers just mentioned (p. 71). The " action " assemblers fell into two groups, to one of which was given the three tests already given to the girls. The ranking for efficiency in assembling was made by the foreman, as the men were not on piece-work. The coefficients obtained were as follows :—

(*a*) Form board (manual dexterity) -	R = +·18
(*b*) ,, (perception of form) -	R = +·56
(*c*) Grip - - - - - -	R = +·29

Here the only test giving a good correlation is the *perception of form* test (*b*).

The remaining " action " assemblers and the group of fifty-one " finishing " assemblers were given the above three tests and the Stenquist mechanical test. (This last test requires the subject to assemble eleven different articles, such as a monkey wrench, a chain, a bicycle-bell, and so on). These groups were ranked for efficiency in assembling by their overseers, as in the earlier cases. The coefficients obtained were as follows :—

For the fifty-one " finishing " assemblers.

(*b*) Form board (perception of form) -	R = +·32
(*d*) Stenquist mechanical test - -	R = +·35

The coefficients for tests (*a*) and (*c*) are not given.

For the "action" assemblers.

(*b*) Form board (perception of form) - R = +·26
(*d*) Stenquist mechanical test - - R = +·34

The coefficients for tests (*a*) and (*c*) are not given.

These results are not so good as those obtained with the small group of girls. They are, however, sufficiently good to encourage research along the same lines, and they indicate the need of repeated experiments in testing the value of tests, especially when the groups tested are small. A coefficient obtained from a small heterogeneous group is of very little, if any, value unless confirmed by other results. The. foreman believed that all the men were not doing their best in the tests, that their full co-operation had not been obtained, and if this were so it probably reduced the coefficients somewhat. In any case, a foreman's views of the relative efficiency of his men are often unreliable.

E. *Dial Machine Operating.*

Link [**43**] describes an interesting attempt to select operators for dial machines by means of a simplified form of dial machine operating. His test consisted in dropping metal balls through a slot in a rotating metal disc. The rate of revolution of the disc was constant, but by varying the size of the slot the same effect was produced as by varying the speed. Success was attained only if the ball was dropped through the slot when in a given position (immediately in front of the subject).

This test was given to ninety-six men dial machine operators in three shops, one of which contained slow while the other two contained fast dial machines. Each operator (one shop excepted) was given three trials of two minutes each, the first two trials with the slot widely open, the third with the slot half closed. The results were correlated with the piece-work earnings of the individual operators calculated for periods of from one to four months. The test was also given to twenty-one women operators. The results showed considerable correspondence between ability in the test and ability to feed the dial machine. The coefficients for the third trial (which gave the best results) varied between +·43 and +·54, the coefficients being calculated for the different shops separately. The faster rate showed greater individual differences than the slower. The size of the coefficients was probably affected adversely by the fact that the operators had been working on the machines for varying lengths of time (p. 120). Apart from these coefficients, the test results separated the *fast* from the *slow* operators. The average performance in the test of a night shift on slow machines was from twenty-five to thirty per cent. poorer than that of a day shift on fast machines (although this may have been *partly* due to the fact that the former group was tested, presumably, by artificial light). The test was considered sufficiently reliable to justify its use in the

employment office, first to eliminate *ab initio* the clumsiest applicants, and second to sort the remainder appropriately for work on the fast and slow machines.

To the preceding groups of operators, the Scott three-hole test was given also. In this test the subject is required to push a plunger successively into three holes placed six inches apart and forming the corners of an equilateral triangle; but the test performance showed no correspondence with efficiency in dial machine operating.

F. *Tool-Making.*

Link [**44**] gave five tests to three groups of tool-makers, aggregating thirty-five men. The members of the first group, with one exception, had been engaged on the work for periods ranging from three to five weeks, at the beginning of which periods they were all quite untrained. For ability to learn the work they were ranked by their chief instructor, the foreman of the shop, with great care (p. 125). The other two groups had had less experience of the work. One had had sixteen sessions of two-and-a-half hours each—a total of four days' work; the other, twelve similar sessions—a total of three days' work. These two latter groups were also ranked by their instructor for their capacity for the work. All three groups were thus in the early stages of training.

Two of the tests used gave no significant correlation coefficients and it is (therefore) not stated what these tests were. The remaining three were :—

(*a*) The *Stenquish* mechanical test;

(*b*) The *cube construction* test (a three-inch cube is painted on every side the same colour, and then cut into twenty-seven one-inch cubes. The large cube is demolished before the subject who is required to rebuild it so that the painted surfaces are on the outside. Each subject was allowed to do this twice—method of scoring not given);

(*c*) A *large form-board* test (p. 124).

These three tests consistently yielded large positive coefficients with all three groups. With the group that had had the longest experience of the work the coefficients of efficiency in the tests with efficiency in the work were as follows :—

(*a*) *Stenquish* test - - - -	R = +·84
(*b*) *Cube construction* test - - -	R = +·75
(*c*) *Form-board* test - - - -	R = +·81
and for the three tests combined - -	R = +·90

The coefficients for the other two groups, although high, were not so high as those for the first group. For these groups only the coefficients of the work with the three tests combined are given. These are : for the second group +·65, and for the third +·50. The numbers of men in the three groups were : twelve in the first, eleven in the second, and twelve in the third. Thus, the groups were all small; but the fact that significant

positive coefficients were obtained with each of them suggests that the tests would be useful for the selection of apprentice tool-makers.

G. *General Engineering Work.*

N. Braunshausen [**45**] thinks that vocational guidance should be based upon an exhaustive examination of the individual, and illustrates this view by obtaining a large number of physical, physiological and psychological measurements from pupils in an engineering institute. Altogether, forty-three measurements were made, eleven physical, thirteen physiological, and nineteen psychological. The range of values under each measurement was divided into five classes (excellent, good, adequate, inadequate, and bad), and complete records are given for thirty-four pupils. The work in which the institute provided training was divided into eleven types—turning, moulding, draughtsmanship, etc.—and an attempt was made to determine by analysis what degree of the functions measured was demanded by each type. From a consideration of a youth's records for all forty-three measurements and a comparison of these with the various occupational requirements, a judgment was made, first, as to the class or classes of work for which he was fitted, secondly, as to the class or classes of work for which he was definitely unfitted, and thirdly, as to the class or classes of work in which he might attain satisfactory efficiency with industry and experience. In most of the thirty-four cases, it seemed that a youth might equally well choose any of several classes of work, and also should definitely *not* choose any of several others. There was thus a certain scope for the operation of interests. The class of work on which each pupil was specialising is also given (p. 23), and if the author's judgments on the vocational aptitudes of the pupils are correct, the choices of the pupils were often at fault. No proof is given of the relevance of the functions measured to the types of work concerned, nor of the suggested minimum standards in these functions for these types of work. Such evidence could be obtained by a follow-up system.

The paper is suggestive from the point of view of method. The number of measurements obtained is probably unnecessarily large, and the practical importance of decreasing it as far as possible is recognised.

Lipmann and Stolzenberg [**46**] set out under thirty-two headings the qualities they consider important for those engaged in the metal industry. The qualities enumerated are such as delicacy of touch, sensitivity to pressure, visual estimation of the lengths of lines, form recognition, mental representation of objects (imagery), immediate memory for spatial order and for words seen and heard, attention and dexterity. Understanding the construction and functions of machines of a simple sort is also included. Finally, certain moral qualities are mentioned, such as the capacity to co-operate in work, the capacity to carry out dangerous tasks, patience, "system," care and neatness.

Most of the qualities are "weighted" according to the authors' conceptions of their relative importance for metal workers, the weights allotted being in the proportions of 1, 2, 3, 4, and 5.

The body of the article consists of a description of tests designed to detect degrees of the specified capacities, several tests often being used for a single capacity; and of the results obtained by giving the tests to twenty-four pupils in one of the lowest metal-working classes of a continuation school in Charlottenberg, and to a number of the older pupils of an elementary school. The tests were given to the pupils in the continuation school in the summer of 1919, these having left the elementary schools in the Easter of that year. Ages are not given.

The tests, though sometimes suggestive, are almost without exception unsatisfactory in their present forms. In testing *delicacy of touch*, for instance, the performance could be carried out partly by sight (pp. 14–17). This is also true of the test for *sensitivity to pressure* (p. 19). Visual estimation of lengths of lines took the form, chiefly, of asking the subject to estimate the lengths of given lines in millimetres: a capacity certainly not innate and in any case of ambiguous relevance to engineering work. The tests for the understanding of the functions of machines—really tests of knowledge of elementary mechanical principles—while suggestive, scarcely test innate capacity (pp. 34–39). On the other hand, the tests for mental representation of sections of objects and for reproduction and recognition of form (pp. 41–50) seem to be worth further investigation. One of these is as follows: five differently shaped objects, and ten drawings representing sections of them, are placed before the subject, who is required to indicate which object should be cut, and in what direction, to give a section indicated in a given drawing (p. 41). A similar test is to indicate what would be the shape of a section if a complex object were cut through in a specified direction (p. 43). The test for attentive observation—and also for patience !—is to select from 189 pieces of thin metal, intended to replace a missing piece in a larger sheet, those that are defective (p. 59). Such a test would probably be valuable as a variant of the traditional *cancellation* tests; but in the form used here, it does not seem to have been sufficiently specified to the subjects what was to constitute a defect. The dexterity test (pp. 51–52) consists of a simple task on a lathe, and seems capable of useful development.

Assuming the relative importance of the various capacities to be as stated, the method adopted for determining fitness for the metal industry is based upon the calculation of different "indices" (pp. 10–13, 72–75). *Roughly*, an "index" corresponds to a percentile grade (a subject's "index" for any test is roughly his percentile grade in it). A subject's "indices" in all the tests of any one capacity are averaged, and the resulting averages for all the subjects are arranged in a new percentile grading which gives the *specified capacity* "index" for each subject. These "indices" are now weighted, according to the assumption that

certain capacities are more important for the metal industry than others, by being multiplied by 1, 2, 3 4, or 5, as the case may be. Thus weighted, each subject's "indices" for *all* the specified capacities are averaged, and the resulting averages for all the subjects are arranged in a final percentile grading which gives a *fitness-for-metal-work* "index" for each subject. The higher this final "index," the more suitable is the subject for the metal industry.

The authors consider that children should be observed while at school to determine whether they possess the foregoing specified capacities or not; and that the observation should be made by the school master, whom they instruct as to the particular qualities likely to be shown in different lessons (pp. 5–9). This represents a very inadequate solution of the vocational guidance problem, even if the master uses the suggested tests. The whole procedure of the authors, indeed, is somewhat lacking in scientific essentials. It is no doubt useful to enumerate provisionally all the qualities that seem to be required for a given sort of occupation; but there is no value whatever in arbitrarily allotting weights to them—as the authors seem partly to recognize (p. 13). The test results given are of no value except to illustrate the "index" method, some form of which must be used whenever several capacities are involved in fitness for a given type of work. Norms of performance could not be obtained from the small number of subjects taking the tests. In any case, it is not worth while obtaining norms for performance in any test until it is known that the test is a satisfactory means of detecting the presence of different degrees of a relevant capacity. The authors, in general, do not show that the tests satisfy this condition, nor do they give evidence that that the various qualities they specify are the important qualities for the engineering trades. Some very slight practical proof of the value of the tests is given (p. 77), but this is clearly inadequate.

Hollingworth and Poffenberger [47] give correlation coefficients of six tests with engineering work, but no account of the investigation in which they were obtained has been published. The tests were: completion, card sorting, "construction," "invention," "omnibus," and "imagination."

H. *Professional Engineering.*

In 1918, C. R. Mann [48] gave a short description of investigations made by E. L. Thorndike into the problem of determining the capacities required by the professional engineer. These investigations formed part of a general enquiry into engineering education in the United States, which resulted from the action of a joint committee representing the principal American engineering societies. This enquiry elicited the fact that, on the average, sixty per cent. of the students who began the courses in the higher branches of engineering, either at universities or technological institutes, were unable to complete them, while of the forty per cent. who graduated about half

only just reached the standard in the fundamental subjects. The need of some better method than the current college entrance examinations or leaving school certificates for determining fitness for the work of a professional engineer, thus seemed obvious.

Thorndike gave a set of fifteen specially constructed tests to thirty-four engineering freshmen at Columbia University, to forty at the Massachusetts Institute of Technology, to forty-one at the University of Cincinatti, and to sixty students at the Wentworth Institute in Boston. Each test was "designed to record the student's relative ability in some one particular activity which was complete in itself," although it involved a rather complicated series of reactions. Thus each student was asked to read paragraphs and write answers to questions on their meaning, to identify words as proof of his range of vocabulary, to supply missing words in sentences, to solve arithmetical and geometrical problems, to perform algebraic computations, to draw graphs from given data, to give geometrical proofs of stated theorems, to solve problems in physics described in words, to arrange physical apparatus to secure specified results, to match each of a series of pictures with one of a series of verbal statements, to supply missing lines in drawings of machinery, and to construct simple mechanical devices from their unassembled parts (pp. 49–50). The character of the tests is more fully indicated in an Appendix (pp. 117–125). The tests differed from the scholastic examinations which at least some of them might be supposed to repeat, by the fact that they were constructed so as to place as little emphasis as possible upon knowledge and as much as possible upon the specific abilities they tested, and by the further fact that the parts of each were arranged in a very carefully graded series according to difficulty.

The testing of the tests was carried out most satisfactorily in the case of the thirty-four Columbia freshmen in engineering. The test results here were compared with a composite rating obtained by combining the students' High School marks in English, mathematics and physics, their ratings in the Regents examinations in these three subjects, their freshman records in English, mathematics and chemistry, the combined judgment of the students concerning one another's intellectual ability, the judgment of the teachers who were acquainted with the men, and the age of entrance to college. Each of the fifteen tests correlated positively with this composite rating, the coefficients varying from $+\cdot 18$ to $+\cdot 796$. When all fifteen tests were combined, the total test rating correlated $+\cdot 84$ with the combined scholastic rating. And by weighting the tests according to the size of their partial coefficients with this scholastic rating, a set of *seven* combined yielded a coefficient of $+\cdot 87$. The giving of these seven tests occupied five hours. It is emphasised that they yielded practically as much information concerning the ability of the students to profit from college courses as all available scholastic sources combined. It is pointed out further that as scholastic ratings are generally recognized to be inadequate

indications of ability, some of the tests yielding low coefficients may really have been testing something important for professional engineering success. At any rate, they tested something which was not taken account of by the scholastic rating. Various interesting details concerning the treatment of the results are given in the Appendix to which reference has been made above.

The primary requisite for the professional engineer is probably "general intelligence," and it is worth mentioning that in the U.S. Army Intelligence tests,* the engineering officers made a higher average score than any other single occupational group. Thorndike's tests, indeed, are very similar to certain traditional "intelligence" tests.

J. *Miscellaneous.*

W. F. Kemble [**49**] describes various tests that may be made with a "Match Board" and match sticks. The match board is a board containing a number of holes of several sizes arranged in a variety of patterns; and in carrying out the test, the subject is required to put match sticks into certain specified holes (as instructed) as rapidly as possible. Sections of the board are used for making different tests (a cut of the complete board is given on p. 14). From his sketchy discussions Kemble appears to have used this test industrially to a considerable extent, to test such capacities as right and left hand dexterity and "ambi-dextrous control." Standards of good, medium and bad performances for right-hand dexterity, obtained with certain girl subjects, are given (p. 12). This test is also alleged (p. 201) to have separated the good workers on piece-rates from the poor workers (though the nature of the work is not described). Generally, however, the author merely allows himself to talk confidently about this or that test. "We have already arrived at the point where we can pick with rarely failing mathematical precision the right person for the right job" (p. 17). The discussions, nevertheless, are often suggestive, and some of the proposed tests are ingenious. The match-board test, in particular, seems to contain possibilities. It has the merits of being extremely simple and unusually easy to score. It would not be surprising if it gave some indication of "factory ability," as its author maintains that it does. (Kemble says that about one girl in ten fails in the test through nervousness). Some of the capacities he tries to test with it, however, could probably be better tested otherwise.

3. Music.

C. E. Seashore [**50**], discussing the aptitudes required by musicians, claims that "in no other field does vocational guidance give so great promise of becoming scientific" (p. 3). In so far as this claim is valid, it depends upon the fact that music requires certain very specific innate capacities: scientific vocational

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* *See* below, pp. 47–49.

guidance has a promising field wherever *specific* capacities are required. Seashore has tabulated the capacities which he considers to be needed by a musician. He has not arrived at these by an empirical use of tests and a correlation of capacity for certain tests with success in music, but by elaborate analysis, theoretical and experimental, of musical activity. In the Psychological Laboratory of Iowa University, he and his research students have worked upon this analysis for the past eighteen years. The results obtained strongly suggest that analysis of an occupation, if made with sufficient knowledge and care, is a possible method of determining the capacities required for it, in cases where correlation evidence is, for one reason or another, difficult to get. The standards set for the different tests, however, seem arbitrary, as indeed they must be, considering the method used. Further, the tests themselves seem not always satisfactory. Thus, a tapping test is used to indicate capacity for rapid movement (often required in instrumental music); but it is doubtful how far a single performance of this test (which is what is used) can indicate this, as H. L. Hollingworth [**51**] found that a first performance of it (with thirteen subjects) correlated only $+\cdot 231$ with performance after practice had been eliminated. (Of course, this result may have been due to special conditions). Seashore recognizes, however, that his tests and analyses are not final, and they will no doubt be put later into a satisfactory form. Some of his tests—for instance, his "serial action" test on the typewriter (pp. 180–181)—should be useful for other purposes than the detection of musical talent. For this test the experimenter first types a full line (70 spaces) of four letters in chance order. This is pasted on to the carrier of the typewriter, and a small card, with a slit just large enough to expose one letter at a time, is clamped in front of it in such a way that each time a key is depressed a new letter is exposed in the slit. There are thus four signals (the four letters), any one of which may be exposed whenever a key is depressed. The subject keeps four specified fingers on the four relevant keys, and reproduces the line of copy as fast as possible. Certain of the auditory tests may also prove useful elsewhere than in music. Some of the results given are interesting from the point of view of the psychology of individual differences (upon which vocational guidance is based). For instance, it is stated that those who are best at discriminating differences of pitch can distinguish pitch differences two hundred times smaller than those who are poorest. The technique of the tests has been developed to allow of their being given to groups in relatively short periods.

4. Printing.

As a result of the drafting of men into the Army during the war, the printing industry in Germany was compelled to utilize a considerable amount of woman labour. But many more

women applied for the vacant positions than could be absorbed. In January, 1917, in Berlin, three hundred applied for seventy vacancies. It therefore became desirable to find rapidly some method of determining which applicants were the most suitable for the work. For this purpose, the following five tests were suggested by O. Lipmann [**52**] :—

(1) A spelling and punctuation test.

(2) The reading aloud of a hastily and badly written paragraph, deliberately strewn with ink-blots.

(3) Setting up a sentence by means of letter types arranged in a simplified "case" containing nine boxes only, the sentence being constructed so that it contained only the nine letters of the simplified case.

(4) Copying a sentence containing thirty-nine words.

(5) Typing twenty-two words from MS. copy with a Blick typewriter.

The *first* test is a test of acquired knowledge. It represented a preliminary minimum requirement. The *second* is analogous to the traditional *completion* test, and may be regarded as a test of "intelligence." The *third* was not intended to measure any special *motor* skill, but *immediate memory span* when reproduction is retarded by the necessity of taking the letters one at a time from the (simplified) case. The number of times the subject looked at the sentence in setting it was taken as a relative measure of this function. The *fourth* test was intended to indicate the *normal* immediate memory span, the method of measurement being the same as for the second. Whatever was tested here, however, certainly normal immediate memory span was not, as the average number of words copied per look was *two* only. The *fifth* was intended to determine special fitness for keyboard composing machines, which were considered less convenient as testing apparatus than the typewriter, since they contained many more keys.

In scoring the tests, the time and the errors were both taken into account.

No attempt was made to determine the applicability of the tests to the printing industry by means of the correlation method. The correlations between the tests themselves were low. Standards of performance for engaging applicants and assigning them to different types of work were nevertheless recommended, on the basis of the performances of sixty applicants who took the tests in the early part of 1917. In considering an applicant's suitability, her average score in the five tests was to be used. The author hoped to obtain confirmation of his opinion of the value of the tests and the standard recommended by keeping under observation for some time those who were engaged as a result of their performance in the tests.

Lipmann's suggestions were almost at once (July, 1917) embodied in the examination of women applicants by the Stuttgart Printing Industry. D. Krais [**53**] gives an account

of the method there adopted (with complete instructions for giving and scoring the tests). It consists of (1) a medical examination (the instruction blank to be filled in by the doctor for each applicant is given, p. 37), (2) a preliminary testing (consisting essentially of tests of handwriting, spelling and punctuation), and (3) a special aptitude testing (consisting broadly of Lipmann's last four tests, with some modification).

A table is given (pp. 26–27) showing the relation between the test performances of twenty-one applicants who had been engaged (at Stuttgart), and the opinions of their supervisors as to their capacity for the printing industry, given six weeks after the women had begun work. Correlation coefficients were not obtained, but there is clearly some correspondence between the two ratings. Though this is by no means perfect, various facts seemed to make the tests well worth retaining. Thus, fourteen women who on the basis of their test performances had been assigned to machines as helpers, were tried by their supervisor at composing (owing to temporary exigencies); but they proved quite unfit for the work, and had to be sent back to the machines (p. 29).

It should be noted that the problem out of which Lipmann's investigation arose is different in many respects from that of selecting suitable apprentices for the printing trade. The differences among young adult women are greater than among fourteen-year-old boys, and tests which proved useful for the former might prove very inadequate for the latter.*

5. Salesmanship.

W. D. Scott [**54**] was one of the first to attempt to determine the qualities required for salesmanship by means of mental tests. He showed that the ordinary method of selecting salesmen (by interviews and recommendations), while not without value, was unsatisfactory, and urged that it should be supplemented by other methods. First of all, a salesman should be medically examined and reach a certain standard of general fitness. Next he should attain a minimum educational standard. Finally, he should have a certain degree of "native ability." It is not stated what the appropriate standards under any of these three heads are. The medical standard is doubtless important for efficiency in all occupations and not merely in selling, and though a travelling salesman should not, for instance, be lame, no suggestion is made that some specific physical condition is the best for general salesmanship efficiency. Concerning the educational minimum required, this would differ in different circumstances.

* Investigations similar in general type to those reviewed in the present Report, and having for their object to determine the capacities required by the hand compositor, have recently been carried out for the Board by the writer; and an account of them will shortly be published in one of the Board's Reports (Report No. 16, "Three Studies in Vocational Selection")

The most important suggestion of the author concerns "native ability," by which he means "general intelligence," and a complex test (said to be one of a series) for detecting individual differences in this capacity is given. It consists of psychological tests of the types known as opposites, verb-object, species-genus, addition, mixed relations, hard directions, and proverb matching. This test has been used by various organisations, though the standards required from applicants for positions as salesman vary. Thus, one concern admits as a satisfactory performance the completion of the test in thirty-three minutes with not more than eighteen mistakes, while another uses a higher standard—twenty minutes for the performance with not more than eight mistakes. It is stated that the most brilliant adult applicants complete the test in about fourteen minutes. Evidence is given to show that tests of this nature are valuable. Salesmen selected on the basis of performance in them were found gradually to arrange themselves in an order for selling ability corresponding to the order of merit in the tests. Selection was not made on the basis of the tests alone, however; apparently, manner appearance and tact were judged by personal interview. General intelligence, is, no doubt, useful for most occupations, and nothing very extraordinary is proved when it is shown that, given certain other qualities, such as tactfulness, the more intelligent a man is the better salesman will he be (within limits). What is required is a determination of the standards of general intelligence most appropriate for different occupations. It should then be possible to determine whether the general intelligence of a given man was above or below the standard for any given type of work. The results obtained for different occupational groups in the U.S. Army tests (*see* below, pp. 47–49) form a starting point for investigations of this kind.

H. Münsterberg [**55**]* gave various tests to twenty-three salesmen and executives in a New England wholesale concern. The subjects were graded for ability in salesmanship or as executives by their supervisors. Comparing the results in the tests for five of the good, with those for five of the poor salesmen, it was found that the five good salesmen made the better performances in *most* of the tests. There were two tests in which the difference between the good and the poor *salesmen* was very great. In these the subjects were required to construct words from letters according to certain directions. In one, the task was to select one letter from each of several given words so as to make some famous American's name; in the other, to rearrange letters so as to make the name of a city or an animal. On the other hand, the results of a *completion* test corresponded best with the efficiency of the *executives* who were tested. All the tests used are described.

Four tests (sentence completion, word completion, word building, and rearrangement of letters) were given to forty

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* *See* bibliography, Burtt, H. E.

employees in an Ohio department store—there were ten good and ten poor executives, and ten good and ten poor salesmen. The good executives were found to be superior to the poor executives in every test, but most markedly in the *sentence completion* test. Negative results were obtained with the salesmen; in none of the tests did the good salesmen do better than the poor salesmen. Various tests were also given to seventy sales-people in a Boston department store. The subjects were arranged in two groups of thirty-five each—one consisting of efficient and the other of inefficient "clerks." The best results here were obtained with the *sentence completion* and *rearrangement of letters* test.

The results are insufficiently precise. As far as they suggest anything, it is that *general intelligence* is an important factor in differentiating the efficient from the inefficient, both salesmen and executives. The *rearrangement of letters* test seems to test "intelligence," while *completion* tests have always been considered to be tests of this "general factor." Several of the tests illustrate Münsterberg's ingenuity.

E. Oschrin [**56**] describes an investigation whose purpose was to find tests which would detect "sales ability of the lower grades." The subjects were eighteen saleswomen who formed a class in salesmanship in a large department store in New York, and who had been engaged in selling for some time.

Thirteen tests were given—Trabue completion test (scale A),* number group checking, opposites, verb-object, substitution, colour naming, hard directions, cancellation, Knox cube, Kent-Rosanoff association test, rearrangement of animals' names, and rearrangement of cities' names. In the last two tests the subjects were required to rearrange jumbled letters so as to make from them the names of animals or cities. (The subjects were told that the letters could be rearranged in the one case to form names of animals and in the other names of cities). Each test contained twenty-four disarranged names, and the score was the number right in 90″. The colour naming and Knox cube tests were given individually. The remaining tests were given to the whole group together, the time allowed for each (with the exception of the "rearrangement" tests) being that of the quickest subject.

Considerable difficulty was experienced in obtaining a satisfactory grading of the subjects for salesmanship ability. The eighteen young women came from fourteen departments, so that no one overseer was acquainted with the capacities of more than a few of them. An attempt was nevertheless made to obtain a grading from the departmental heads by requesting them to use a rating scale of five divisions. A grading was also attempted on the basis of salary, but this was unsatisfactory because salary was dependent upon length of service and upon department. The most reliable grading was probably that made

* *See* note to p. 16 above.

by the teacher of salesmanship after six weeks' knowledge of all the subjects through teaching them.

The following significant positive coefficients were obtained between the teacher's grading for salesmanship ability and the results for the undermentioned tests : the remaining tests gave lower coefficients (p. 153).

Tests.	Correlation Coefficients.
Opposites	R = +·65
Mixed relations	R = +·50
Rearrangement of animals	R = +·45
Number group checking	R = +·43
Cancellation	R = +·41
Hard directions	R = +·41

The coefficient of these six tests combined and salesmanship ability (as expressed in the teacher's grading) was +·76. The author concludes that the first three of these tests are useful diagnostic instruments of salesmanship ability of the lower grades. It is noteworthy that they are all " intelligence " tests.

6. Telegraphy.

In 1915 E. S. Jones [**57**] gave twenty-two boys (fifteen years of age) who had received eight months' instruction and practice in telegraphy at the Telegraph Boys Continuation School of Cincinnati, and who were employed partly as messengers by the Western Union Telegraph Company, the series of mental and physical tests used by Woolley and Fischer [**58**] in determining norms for working children. The test performances were correlated with the preliminary and final judgments of the two teachers (made at the beginning and at the end of the eight months of instruction) as to the relative telegraphic ability of the boys. These gradings of the two teachers correlated highly : +·81 for the preliminary judgments and +·91 for the final judgments.

Three tests—opposites, completion, and immediate memory for series of digits—gave significant positive correlation coefficients with telegraphic ability (as expressed in the gradings of the teachers). The results for these tests combined gave coefficients of +·61 with one teacher's preliminary grading and +·79 with the other's, and +·81 with one teacher's final grading and +·76 with the other's. The correlation of the school standard completed with the teacher's gradings gave coefficients almost as high as these. The coefficients of the tests with efficiency as messengers were lower, though significant. It is noted that six boys who were hopeless in telegraphy were bottom in the psychological tests.

An interesting analysis of the work of the wireless telegraph operator is given by O. Lipmann [**59**]. He distinguishes sharply

the capacities required for sending messages from those required for receiving, and contends that the latter are by far the more complex, and also the more important from a vocational point of view, since sending may be carried out by mechanical apparatus, whereas a mechanical method of receiving does not seem possible. Capacities enumerated as required by the receiver are (1) auditory sensitivity to tones of a vibration frequency of from 500 to 1,000, (2) low differential threshold for pitch and intensity of sound, (3) absolute memory for pitch (considered useful but not essential), (4) sense of rhythm, especially the capacity to recognise rhythms and distinguish one from another, (5) intelligence of the kind that can rapidly grasp the meaning of signs and fill in gaps in series of signs, (6) relative non-distractibility of attention. Interesting psychological observations are made on these and other points; for example, on the effect of the imagery type of a subject upon the kind of errors he makes in perceiving material through the different senses, and on the " Tempo " which seems peculiar to a given individual. Concerning the last point, it is stated that wireless operators are divisible into three classes on the basis of " Tempo "; those who can receive about sixty letters a minute, those who can receive from sixty to eighty, and those who can receive from eighty to one hundred. It is considered that an operator should be in at least the first of these classes.

Lipmann's analysis should prove valuable for any further investigations into the problem of selective tests for this occupation. He himself, however, proceeded by the method of constructing a test which was a miniature of the work. This involved five characters of the forty-six constituting the Morse alphabet (k, m, r, s, and v). It occupied about an hour, during which the signs had to be learnt, to be recognised when given in various combinations, at various rates, and along with distracting stimuli in the form of other sounds. An applicant's relative performance in this test was considered indicative of his relative capacity to deal with the full alphabet under actual conditions. The test results are given for seventy-one subjects, who had had no acquaintance with the Morse alphabet earlier, and these are arranged in percentiles. But the investigation included no attempt to establish the value of the test by correlating results obtained by its use with results given in operating.

L. L. Thurstone [**60**] gives some correlation coefficients between the results of each of eight tests and efficiency in radio-telegraphy judged by *sending* speed, after one hundred hours practice in the work. The tests were given in 1917 to one hundred and sixty-five drafted men, whose ages fell between twenty-one and thirty-one.

The tests were : (*a*) a rhythm test, the subjects being required to reproduce rhythms of different patterns and complexity; (*b*) an opposites test; (*c*) an analogies (mixed relations) test; (*d*) a directions test; (*e*) a completion test; (*f*) a spelling test; (*g*) an arithmetic test; and (*h*) a " sentence " test.

The highest coefficients were obtained with the rhythm and opposites tests, these being +·48 and +·42 respectively (*p.e.* =·06 and ·04).

No relation was shown between ability to learn telegraphy and previous occupation, nor between this ability and the kind and degree of education, college graduates showing no more aptitude for the work than men who had never entered college. On the other hand, education was found to be a very reliable guide when placing men as repairers of wireless apparatus. The author considers that the ability for wireless operating is probably quite specific, and that here at any rate vocational fitness is not dependent primarily on intelligence. At the same time, the opposites test—an intelligence test—yielded the second highest correlation.

The combined results of the five tests yielding the largest correlation coefficients with efficiency in sending (*a* to *e* above) correlated +·53 (*p.e.* =·04) with this efficiency. It is pointed out that the rhythm test alone yielded a correlation of +·48, and that this was therefore not raised to any extent by the addition of "four of our best intelligence tests." This emphasis on rhythm agrees, so far, with Lipmann's theoretical analysis, and the latter's "miniature" test was such as to bring the element of rhythm into prominence.

7. Telephone Operating.

H. Münsterberg [**61**] describes an investigation which aimed to determine tests for selecting telephone operators. He first made an observational analysis of this work, and then gave tests for various elements of it to about thirty young women training at a telephone school. The ages of these subjects ranged from seventeen to twenty-three. They were given the following eight tests, the first five collectively, the remainder individually :—

(*a*) an *immediate memory span* test (the material consisted of digits);

(*b*) a *cancellation* test (striking through with a pencil every *a* in the morning's newspaper for six minutes);

(*c*) a *logical memory* test (twenty-four pairs of words were read to the subjects, each pair logically connected in some way; after which the subjects were required to reproduce the second word of each pair upon being given the first);

(*d*) a *spatial judgment* test (bisecting two lengths);

(*e*) a *rapidity of movement* test (drawing as many zigzag lines as possible with a pencil in ten seconds, the length of the lines being fixed by the experimenter);

(*f*) a *card sorting* test (sorting a pack of forty-eight cards into four piles);

(*g*) an *accuracy of movement* test (attempting to strike with a pencil, in rhythm with the beats of a metronome,

the points of intersection of three crosses—one of the movements required complete extension of the arm);

(*h*) a *speed of association* test (average association time for six words).

Methods of scoring are given for most of these tests.

The subjects were ranked on their total efficiency in the tests by averaging the ranks of each subject in all eight tests. The ranking thus obtained for the group was compared with that for efficiency in learning telephone operating, this being judged by the instructor after the subjects had been three months in training. Correlation coefficients are not given, but the result of the comparison was " on the whole satisfactory " (p. 108). With a few exceptions, those who gave the best performances in the tests were ranked highest by their instructor for telephone operating, while those placed lowest for this work were found to have given the poorest test performances. Several fully trained operators, who had been given the tests along with the beginners, as a sort of control, gave the best performances in the tests, which suggests that the functions tested were receiving practice in operating and could thus validly be made the basis of selection. It is noted that " those who stood the lowest in the psychological rank list had in the meantime (during the three months) been found unfit in practical service and had either left . . . or been eliminated " (p. 109). It is also observed that the method of averaging the rankings in the various tests assumes that the tests are all of equal value for selection, while some are possibly much more valuable than others (pp. 107–108). The author concludes that by the perfecting of the methods here used it should be possible, by means of an experiment lasting only a few minutes, to save thousands of applicants for telephone operating months of training which would otherwise be completely wasted because of their ultimate unsuitability for this work (p. 110).

H. C. McComas [**62**] tested nine operators from the Princeton Telephone Exchange with two tests, one of which attempted to reproduce the character of the work in the Exchange by means of a miniature switchboard, while the other was an eye-hand co-ordination test—the aiming test. In the *switchboard* test, the time taken by the operators to make " connexions " was recorded, and the subjects were ranked according to their quickness in making fifty connexions in succession. This ranking was compared with the rankings obtained independently from two of the supervisors at the Exchange, who ranked the operators according to the efficiency shown in their work. The test detected the two best, and two out of the three poorest operators. In the *aiming* test the subjects were required to strike with a pencil the points of intersection of crosses, the paper containing the crosses being placed upright on a table before the subjects. They were required to bring the pencil down to the table after each thrust in order to imitate the plugging movement in the

actual work, and were instructed to proceed as quickly as possible without sacrificing accuracy. Tests were made with each hand. The ranking obtained with this test correlated $+\cdot 625$ (*p.e.* $= \cdot 14$) with the rankings of the Exchange supervisors. The published account of the work does not give details.

Fontègne and Solari [**63**] give a lengthy account of telephone operating in a large Exchange in Geneva, and of experiments made with the object of determining the capacities required for this work. They note that this occupation is inevitably fatiguing. All the operators who were questioned, except one, stated that they experienced in their work a more or less severe fatigue, which showed itself subjectively in considerable discomfort and objectively in the occurrence of mistakes. The investigation was carried out in the hope that the application of its results might help to lessen the telephone operators' fatigue.

Subjects.—These were twenty-seven girl operators whose capacities for their work were known to the management of the Exchange, and a number of pupils at a commercial institute.

Tests.—The following capacities were tested :—

(1) *Immediate Memory.*—The material consisted of two series of groups of digits gradually increasing in number, the smallest group containing three and the largest ten digits. These were presented to the subjects orally, and reproduction in writing was required immediately after each group had been presented.

(2) *Serial Memory.*—A series of ten names of cities was read to the subjects, who were required to reproduce the series in writing ten seconds after the last name had been spoken. This was supplemented by a series of four four-place numbers, the whole series being read to the subjects, who were required to reproduce it immediately afterwards. (The authors fail to observe that (1) is also a " serial " memory test).

(3) *Attention.*—This was a cancellation test. The subjects were given printed matter in a language foreign to them, and required to cross out, for six minutes, every *i*, *a*, *u* and *s*. Two scorings were made, one for quantity alone and the other for quality, which was measured by percentage of errors.

(4) *Spatial Judgment.*—The subjects were required to strike with a pencil in a rhythm determined by a metronome set at 100, the central point of certain sections of a sheet of paper, including the centre of the whole sheet. The sections were those that would have been made by folding the sheet in certain ways, the subject having to *imagine* where the boundary lines of such foldings would lie. The test was made with both hands (one at a time).

(5) *Rapidity of Movement.*—Two tests were used. (*a*) Tapping with both hands (one at a time) at the greatest possible rate on a Morse key for 30″. (*b*) Sorting cards into four boxes.

(6) *Accuracy of Movement.*—The subjects were required to strike the points of intersection of crosses printed on a sheet of paper which was fastened to the wall of a room—the standard aiming test. The test was made with both hands (one at a time), the target being at arm's length.

(7) *Reaction Time.*—This was taken with a Hipp's chronoscope. One hundred sensory reactions to visual stimuli were obtained—fifty with the right and fifty with the left hand—preceded by five practice reactions. Two scorings were made, one the average time and the other the mean variation (referred to as *Time of Reaction* and "*Precision*" *of Reaction* respectively).

(8) In addition to the foregoing, the *manual asymmetry* of the subjects was calculated for each of four of the tests (spatial judgment, aiming, tapping, and "precision" of reaction), and the results combined into a single coefficient of asymmetry for each subject by averaging the coefficients for each of the four tests. The formula used for obtaining this coefficient (c) for any test was—

$$c = \frac{r - l}{\frac{(r + l)}{2}}$$

where r = right-hand result and l = left-hand result.

Results.—The important results are the correlation coefficients of the tests with the telephone operating ability of the twenty-seven girl operators. For the purpose of calculating these, the girls were arranged in order by the manager from the best to the poorest (in their work). Arranged in order of size, the coefficients were as follows :—

Tests.	Coefficient of Correlation.
1. Immediate memory	$r = +\cdot 466$
2. Attention (cancellation—*quantity*)	$r = +\cdot 458$
3. Card-sorting—("rapidity of movement")	$r = +\cdot 434$
4. "Serial" memory	$r = +\cdot 421$
5. "Precision" of reaction (*m.v.* of reaction-times)	$r = +\cdot 320$
6. Accuracy of movement (aiming)	$r = +\cdot 264$
7. Attention (cancellation—*quality*)	$r = +\cdot 239$
8. Reaction-time (average time)	$r = +\cdot 239$
9. Manual asymmetry	$r = +\cdot 031$
10. Tapping (rapidity of movement)	$r = +\cdot 021$
11. Spatial judgment	$r = -\cdot 436$

The ranks of each subject in these eleven tests (counting *manual asymmetry* as a test) were then averaged, and the resulting ranking for the group yielded a correlation coefficient with their work ranking of $+\cdot 541$ (*p.e.* $= \cdot 091$). When only the first eight tests were treated in this way (the last three being negligible)

the resulting coefficient was +·698. This is sufficiently high to indicate that the total performance in these eight tests would be valuable in selecting girls for telephone operating.

For future use, a table of percentile performances for each test was arranged, based upon the performances of these subjects. Any applicant's performance could then be compared with the figures in this table, and her percentile grade could thus be determined in each test, and in the best eight tests combined. While this method is correct in principle, the calculation of percentiles from twenty-seven subjects cannot yield a valid result. Further, the capacities tested, in so far as they definitely were exercised in the work, would be more developed in the actual subjects of the experiments than in chance applicants. Hence, an applicant might occupy a much lower percentile grade at application than after some months' practice at the work. A table of percentile performances in the relevant tests should be constructed from an investigation with subjects of the kind who would actually become applicants—say, with girls who had lately left school. An applicant's performance in the tests could then be compared with the average performance of those of her age and experience.

The only other results given are the averages (in some of the tests) obtained from the pupils of the commercial institute. These were generally lower than those of the girl operators, a fact which strengthens the idea that practice in any work increases the capacity for the performance of tests definitely relevant to it.

From this investigation it may be concluded that a relatively high degree of the following psychological capacities help to fit a girl to become a telephone operator :—

(*a*) immediate auditory memory for numbers;
(*b*) immediate "serial" memory;
(*c*) sustained attention;
(*d*) rapidity of movement;
(*e*) accuracy of movement;
(*f*) relatively quick reaction to visual stimuli.

To these psychological capacities certain physiological qualities must be added, especially if selection is to be used to lessen fatigue. These include : (*a*) good eyesight—especially, strong and well-balanced eye-muscles; (*b*) good hearing; (*c*) a certain height. (The authors might have added strong ankles).

The authors raise numerous points relevant to investigations of this type, and to telephone operating in particular. It is interesting that they used no test of "general intelligence.'

8. Transport Work.

Tests of fitness for persons in certain responsible positions in transport service have a social significance which renders their importance obvious. To devise such tests several investiga-

tions have been made, the first being that of H. Münsterberg (*see* below). These investigations are especially interesting because each took its point of departure from the results of such earlier work on the problem as had been carried out, and the attention of the investigators has been directed throughout upon *an analysis* of the occupations concerned, the tests devised having a direct relation to the results of such analyses. There can be little doubt, also, that these investigations have gone some distance towards the solution of their problem.

A. *Ship's Officers.*

H. Münsterberg [**64**] describes an attempt to obtain a test which would exclude from responsible positions in the marine service persons whose psycho-physiological constitution prevented them from making rapid and accurate judgments. (The two types to be specially excluded were :—

(*a*) those who are paralysed by sudden danger, even though they possess adequate *knowledge;*

(*b*) those whose perception of danger so emphasizes the impulse to action that they make bad judgments as to what ought to be done.)

A card-sorting test was devised for this purpose. On each of twenty-four cards were written four rows of the capital letters A, E, O, U, twelve letters in each row, arranged in a chance order. On each of four cards, one of the letters appeared twenty-one times and the other three nine times each; on each of another eight cards, one of the letters appeared eighteen times and the other three ten times each; on each of another eight cards, one of the letters appeared fifteen times and each of the other three eleven times; and on each of the remaining four cards, one letter appeared sixteen times and each of the other three eight times, while in this case eight consonants were also distributed among the vowels. The subject was required to sort the cards into four piles, one of which contained all the cards on which A was the most frequent letter, another all the cards on which E was the most frequent letter, and so on. The score was the time taken to sort the cards (this time being corrected for errors). Methods are given for evaluating the different kinds of mistakes, and also some results; but no tests were made to investigate the reliability of the test as a means of detecting persons who might become unsatisfactory marine officers.

B. *Electric Street-Car Drivers.*

H. Münsterberg [**65**] describes a test devised by him for selecting electric street-car drivers. Analysis of the work suggested that the essential function required for it was a complicated activity of discriminative attention. The material devised for testing this function consisted of a diagrammatic representation of a street and different types of moving objects.

Two parallel lines running through the centre of a card lengthwise represented the car track. The whole card was divided into small squares in certain of which the digits 1, 2, and 3 were placed, the digit 1 representing a slow-moving pedestrian, the digit 2 a horse going twice as fast as a pedestrian, and the digit 3 a motor driven vehicle going three times as fast as a pedestrian. Objects moving across the track were coloured *red*, those moving parallel with it *black*. Each square *along the track* was lettered from A to Z. The subject was required to name as fast as possible the squares on the track threatened by the red digits. The complete test consisted of twelve similar cards. The mechanical apparatus for exposing the cards and the method adopted for scoring the results are described in detail.

This test was given to a number of men employed as drivers by an electric street-car company. They were of three classes—good, medium, and bad—this classification being based upon their records for accidents. The results shewed a "far-reaching "correspondence between efficiency in the experiment and effi- "ciency in the actual service" (p. 75). It was stated by the subjects that in carrying out the test they had the same sort of feeling as when driving a car along a crowded thoroughfare.

While the results of this experiment were not unsatisfactory, it seems likely that a more valuable test than that employed could be devised if sufficient thought were given to the problem. It would have been interesting, also, to have given to these subjects the card-sorting test devised by Münsterberg for the marine service. Further, admitting the *value* of the particular test used here, it may be doubted how far it is a test of the particular activity of attention to test which it was constructed. C. Burt [66] contends that the test was successful because it picked out those who were above the average for *general intelligence*, arguing that *general intelligence* is required for car driving as well as a special form of discriminative attention. He found that this test, when given to children and young adults, correlated from +·43 to +·61 with "general intelligence" as measured by other methods. He points out that Münsterberg himself stated that the *poorest* performance in the test made by graduate students in psychology at Harvard was better than the *best* performance made by the drivers, and assumes that the great difference between these two groups was in degree of intelligence. This is not altogether convincing, because there was at least one other very important difference between the groups: the graduate group was used to tests and the industrial group of car drivers was not. This by itself might account for the difference in the results. The criticism, in any case, concerns the interpretation of the test and not its value. Münsterberg concludes that the poorest twenty-five per cent. of car drivers could be prevented from entering the service if this test were given to all applicants.

In 1917, W. Stern [67] was asked by the Directress of Vocational Guidance for Women in Altona (Hamburg) if he could

suggest a method for selecting suitable women for street-car driving from among the applicants for that position. In consequence, he tested six applicants with an apparatus in essentials not unlike that devised by Münsterberg. A strip of paper on which were written four hundred and sixteen letters was made to pass at a constant rate behind a small window in front of which the subject was seated. Each letter was exposed for four-fifths of a second and a specified reaction or no reaction was required according to the letter exposed. The letters were all black except twelve, which were red. The subject was required to press an electric key with the *right* hand whenever an *s* or *a* or *g* was exposed, whether black or red, and to move a lever with the *left* hand whenever *any* red letter was exposed. This involved a certain number of reactions with each hand separately, and a certain number with both hands simultaneously —namely, whenever the letter exposed was a red *s* or *a* or *g*. Different types of error and average reaction times were noted. The explanations required before the subjects realized exactly what was required of them were used as a rough test of intelligence.

The results for the six applicants are given in detail (p. 10). Individual differences were large. The performances of two were considered so poor that they were rejected (though it is not clear why a third—subject No. 1—was not rejected also). After four months at the work the opinion of the street car management was sought concerning the capacities of the four who had been engaged. The applicant who had made the best test performance had unfortunately left the work (for extrinsic reasons) almost as soon as she had been engaged. Of the other three, the opinions of the management agreed entirely with the results of the test in the case of two, but in the case of the third there was disagreement, the test giving her a poor rating and the management a good one. Stern explains this subject's satisfactory performance in the work as a result of practice.

What is required, however, are tests which indicate those who will improve with practice up to a satisfactory point in any given occupation. The fact is stressed that none of those who did well in the test failed in the work. While this is true, its importance would have been greater had the number of subjects been larger.

Various suggestions are made for a more satisfactory test (pp. 13–16).

H. Sachs [68] describes an experiment in which a still more elaborate apparatus, constructed at the Hamburg Psychological Laboratory, was used to test twenty street-car drivers. The subject stands before an endless black band about 13 cm. broad, a length of about 130 cm. being visible, which travels towards him at a constant rate. Single holes and pairs of holes appear in this band at various distances from one another, the former indicating pedestrians and the latter vehicles. By means of a series of lamps, any single hole or pair of holes can be illuminated at different distances from the subject. The danger from a

" vehicle " is always greater than that from a " pedestrian," and the danger from either is increased in proportion to its nearness to the subject. According to the degree of danger, one of three responses is required : the ringing of a bell with the foot, the moving of a lever with the left hand, and the " putting on of a brake " with the right hand. The conditions in which these responses are respectively required are defined.

On either side of the moving band, and at some distance from it, are two boxes, each containing a single hole and a pair of holes, either of which can be illuminated independently of the other. These when illuminated represent sudden emergences of pedestrians or vehicles from either side of the track, and the reactions then required are the same as those required for corresponding stimuli on the moving band. Finally, a coloured light, situated some distance from the apparatus, is switched on and off intermittently, and the subject is required to count the number of times this occurs. All stimuli and reactions are recorded on an electrically-driven smoked drum. A diagram and photograph of the apparatus are given.

The procedure for the test is first thoroughly explained to the subject, who is then given a preliminary trial for about twelve minutes, after which comes the test proper, occupying about twenty minutes.

The chief point in the results is the number of inaccurate responses. When scored for inaccuracy, a very considerable correspondence (correlation coefficients were not obtained) was shown between the test results and the judgments of the street-car companies concerning the drivers. A comparison of the results with these judgments is given in some detail (pp. 20, 22). Generally speaking, if a man's performance in the test was poor, his record as a driver was bad; but in several instances a subject was placed relatively higher by the test than by the company for which he worked. To explain this, it is suggested that certain relevant qualities were possibly not tested. A sense of responsibility is doubtless necessary for a driver, but its presence or absence would not be indicated by the test used. In seeking for the cause of street-car accidents (which were taken into account in rating the drivers) the taking of alcohol should clearly be investigated also.

The counting of the flashes of coloured light, and also to some extent the reactions to the lights in the boxes on either side of the travelling band, were intended to test the *distribution of attention*. *Type of attention* and *manner of reaction* to stimuli of different kinds were considered the central functions upon which street-car driving depends. In an introduction, W. Stern gives an interesting analysis of the street-car driver's work, and urges the necessity of including in any selection test for this occupation certain stimuli which *may* become reaction stimuli in specified conditions. Thus, the holes on the moving band might be illuminated or not, and were only *reaction* stimuli when illuminated.

The apparatus described in this paper is perhaps the best so far devised for selecting for such work as that of the street-car driver. While certain modifications suggest themselves, the test should certainly be considered in any further investigation of this occupation. Researches with a view to obtaining a perfectly adequate test are said to be proceeding at the Hamburg Psychological Laboratory.

9. War Experiments.

When the war broke out, it became necessary to allocate large numbers of men to "occupations" for which they had had no training. The trial and error method of placing them was soon seen to be very inadequate, and attempts were made in every belligerent country to develop scientific methods for the quick detection of suitable men for various positions. Many of these are in themselves of no industrial interest; but the methods employed often illustrated principles capable of industrial application, and it is mainly for this reason that reference is made to them here.

The most spectacular application of tests to enlisted men was that of the Committee on Classification of Personnel in the U.S. Army. Various accounts have been given of this work, but probably the best is that by Yoakum and Yerkes [69]. This application of psychological tests was made (by authority of the Surgeon-General) under the direction of a Committee of Psychologists, whose chairman was Major R. M. Yerkes. The tests aimed primarily at the grading of recruits by their *intelligence*, the original motive being the great importance of finding quickly those at the two ends of the intelligence scale. A set of eight tests was finally developed for all literates, and was given to men in groups ranging, according to building facilities, up to five hundred. About fifty minutes was required for this, and about twenty-four hours for analysing and tabulating results. The illiterates—a large body—and those who failed in the test for literates, were given group tests similar in principle to the tests for literates, but not involving the use of language. And those who failed in these were given intelligence tests individually, in case the group tests had treated them unjustly.

At the date of the signing of the Armistice, these tests had been given to one and three-quarter millions of recruits. On the results, the men were placed in five broad classes, from the most intelligent to the least. That the classification thus arrived at was reliable was proved repeatedly and in numerous ways. For instance, when the tests were given to chance groups of men of different ranks, it was found that the officers made rather better scores than the men in O.T.C. camps, that these made distinctly better scores than sergeants, that sergeants made rather better scores than corporals, that corporals made better scores than privates, and that the best privates made better

scores than the poorest (pp. 27, 29). The broad results indicate the complete feasibility of distinguishing different grades of intelligence by means of standardised psychological tests and methods.

Apart from points of method and technique in the giving of tests, probably the result most relevant to industry was the positions on the intelligence scale of different occupations (pp. 196–200). The average degree of intelligence was found to be different in different occupational groups. In order of diminishing intelligence these groups were :—

(1) The professions (with engineers at the top);
(2) clerical workers;
(3) skilled trades;
(4) partially skilled labour;
(5) unskilled labour.

Within each group, further distinctions between occupations on the basis of average intelligence were shown. A complete statement of these results is given in an official (U.S.) publication entitled *Army Mental Tests* (p. 23), of date November 22, 1918. The results are said to be not altogether comparable with those that would be obtained from the civilian population because of various selectional factors which operate in the Army; but they agree with the conclusions of general considerations, and constitute at least a starting point for a comprehensive vocational guidance policy. Intelligence surveys might be made in the higher grades of the schools, and such surveys should yield definite indication of the broad occupational group for which a boy or girl is naturally fitted.

In addition to the fact that clerical workers tend to occupy a definite position on the intelligence scale, it was found (Yoakum and Yerkes, p. 201) that those of them who obtained the higher scores in the tests were more successful in their work than the remainder; that is, that *within* the clerical group intelligence and clerical efficiency were positively correlated. This result is contrasted (pp. 201–203) with that for one hundred and six girl machine operators. These showed a fairly wide range of intelligence in the tests, but their output showed a small negative correlation with intelligence score: —·087. Of especial interest here is the fact that neither the most nor the least intelligent were producing output comparable with those who were nearer the general average. This suggests that the degree of intelligence represented by this average was valuable for efficiency in this particular work, but that greater intelligence than this did not make for greater efficiency, and that both the most and least intelligent girls were here wrongly placed. The case is one instance tending to support the view that different occupational groups represent different intelligence levels.

Besides using " intelligence " tests, the personnel department found it necessary to select men for many occupations on the basis of their knowledge and skill in these occupations rather

than on the basis of aptitude for them. This led to the development of the "Army Trade Tests." * A man claiming experience as a blacksmith, for instance, was given a carefully-planned blacksmith's job to carry out and was asked various critical questions; and a similar procedure was followed in other cases. The trade tests are of little, if any, value for vocational guidance, though the method by which they were developed is of some technical importance. Probably the most suggestive result of this work was the fact that the intellectual factor seemed the dominating factor in many trades ordinarily classified as "skilled" [70].†

In most other countries, selection took the form, chiefly, of endeavouring to find tests which would pick out the right men for *special* types of work, such as sound-ranging, hydrophone listening, or flying. Thus, H. Head [71] investigated the value of certain tests in use for the selection of flying candidates, and pointed out that one of these was "more likely to show ability to dance than any capacity to fly" (p. 9). This work illustrates the necessity of getting evidence that a suggested selection test is really a test of fitness or unfitness. M. Flack [72] carried out various investigations into respiratory tests in relation to flying. L. E. Stamm [73] obtained considerable correspondence between flying record and a choice-reaction test. An account of American results of investigations into flying capacity is given by V. A. C. Henmon [74], and also by Stratton, McComas, Coover and Bagby [75]. W. Benary [76] and Benary, Kronfeld, Stern and Selz [77] give accounts of some of the German work on this problem. Many of the special war experiments have naturally not been published.

10. Miscellaneous.

Hollingworth and Poffenberger [78] give a number of correlation coefficients of tests of various kinds, and—

(*a*) hand sewing;
(*b*) label pasting; and
(*c*) machine stitching.

The investigations concerned have not been published. It is interesting that *intelligence* tests give significant positive coefficients with each of these three types of work, and that dexterity tests were hardly used at all (p. 199).

L. M. Terman [79] describes an attempt to utilize intelligence tests, including the Stanford-Binet, for the selection of policeman and firemen. Applicants making poor scores in the tests were rejected. No direct evidence could be given of the value of the procedure.

* An account of these has recently been given in "*The Scientific Measurement of Trade Proficiency*," by J. C. Chapman. (Harrop & Co., 1921.)

† *See* bibliography, Robinson.

K. M. Cowdery [**80**] carried out an investigation to determine to what extent general intelligence, as measured by the Stanford-Binet scale, is a factor in the vocational progress of delinquent boys. The author concludes on the basis of results for over five hundred boys that innate intelligence is a positive factor in successful progress under the given conditions.

G. Ordahl [**81**] gives comparative results for normal and mentally defective women in work connected with the canning of fruit. On the average, the efficiency of the defectives was found to be about sixty per cent. of that of the normals, and in general the greater the intelligence of the defectives the higher was their efficiency. Among the most intelligent of them, however—the high grade morons—there were some of a rather "hysterical" temperament, and at peeling tomatoes these proved no more efficient than high grade imbeciles, though yielding a much higher "intelligence quotient" than the latter. The hysterical group proved efficient in ironing and cleaning, where fine adjustments were not constantly required. The paper is suggestive from the point of view of the question: To what extent and in what vocations can the mentally deficient become self-supporting?

In a short paper A. S. Otis [**82**] states the broad results obtained from the application of thirteen "intelligence" tests to four hundred silk mill workers. The conclusion drawn from these results is that "intelligence is not only not required in a "modern silk mill for most operations but may even be a detriment "to steady efficient work." This is explained by reference to the great efficiency of the machinery used and the consequent routine character of the operations. Such a conclusion is clearly of great importance in connexion with the problem of occupational intelligence levels.

PART III.—FUTURE INVESTIGATIONS.

While the investigations that have been reviewed suggest that a scientific vocational guidance policy is certainly possible, it is difficult to assess the value of many of the results. The investigations not infrequently give the impression of somewhat rough and ready attempts to solve practical problems; and there is sometimes about them an air of accidentalism both as regards the persons upon whom tests were made and also as regards the tests that have been used. Different investigators, attempting to discover the capacities required for the same occupation, have sometimes obtained significant positive correlation coefficients with very different tests. In such instances, the conclusions of the investigators are probably individually one-sided and require to be combined.

What seems necessary now is a far more systematic and sustained investigation into the capacities required for different

occupations than has hitherto been attempted If a sound basis is to be obtained for vocational guidance, occasional investigations of the type reviewed, the possibility of which depends upon the willingness of a few employers and groups of workers to co-operate with the scientific investigator, while suggestive and useful up to a certain point, are insufficient.

A more adequate method of investigation suggests itself. Large numbers of young persons who are about to enter industry might receive a thorough psycho-physiological examination. As far as possible, they should be re-examined annually for several years, first to guard against errors, always possible in a single examination, and secondly to determine what changes, if any, are produced in the ability to carry out different tests by working at different occupations. During a period of from seven to ten years, an exact record should be kept of the industrial history of those who are examined, and their success or failure in different occupations should be correlated with their psycho-physiological constitution. Within a decade, an investigation of this nature, if carried out systematically and extensively, should lay a satisfactorily scientific foundation for a national vocational guidance policy.*

The points to be emphasised concern—

(1) the exact nature of the problems to be investigated; and

(2) the methods of investigation.

In view of the investigations above reviewed, the *problems* may be stated as follows :—

A. to determine the *general intelligence* level required by each occupation. This determination could possibly be made by means of L. M. Terman's modification of the Binet tests [**83**].

B. to determine the *special* capacities (including physiological characteristics) required by each occupation;

C. to determine the relation of *temperamental* qualities to efficiency in different occupations.

Concerning general *methods*, it is suggested :—

D. that investigations similar in type to those reviewed should be carried out in as large a variety of occupations as possible;

E. that, in addition, extensive investigations, to be continued over a number of years, should be inaugurated, for the purpose of making psycho-physiological measurements of young persons in different occupations and of comparing such measurements with occupational records.

Cf. the following statement, written in 1914 : "At least one good way of testing the usefulness of experimental psychology as a guide in vocational advising, is to apply a representative series of psychological tests to a large and fairly homogeneous group of young people and then find out how much, if any, correlation exists between the outcome of the tests, and industrial success or failure in various directions." *Mental and Physical Measurements of Working Children* (p. 7), by Woolley and Fischer [**58**].

APPENDIX.

The Bicycle-Ball Case.

The selection of bicycle-ball inspectors described by F. W. Taylor has frequently been used to illustrate the economic possibilities of scientific selection in general. As the usual conception of this case is inaccurate and as Taylor's account of it in *The Principles of Scientific Management*, is misleading* (even if it be read very carefully), it is important to state what the real facts were.

The common view as to what was done has been determined by Taylor's statements in *The Principles of Scientific Management*. This account suggests that a visual reaction-time test was made the basis of selection, and that 35 girls selected by this test accomplished more work in a given time than 120 unselected girls had previously accomplished. The increased average (individual) output of about 340 per cent. is supposed to have been chiefly due to the greater psychological adaptation of the selected girls to the work of inspection. If this supposition were true, the selected girls must have shown an average reaction-time about one-third of that of the unselected girls, and though this is not impossible it seems unlikely.

The facts are, however, that no reaction-time test was given, and that the increased individual output was due to a number of factors of which selection was possibly not the most important.

These conclusions are derived partly from a comparison of the two accounts of the case given by Taylor, and partly from external evidence.† In addition to the account in *The Principles of Scientific Management* (pp. 86–97, 1917 *edition*), Taylor has described the case in *Shop Management* (pp. 85–91, 1911 *edition*). The *Shop Management* account is the earlier, having been first published in 1903,‡ when it was read before the American Society of Mechanical Engineers, while *The Principles* was not published until 1911. The two accounts exhibit important differences, which arise from the fact that Taylor's purpose in writing one of them was different from that in writing the other. In each the extraordinary increase of individual output is emphasized; but it is attributed in one account chiefly to one factor and in the other chiefly to others. In fact, while in *The Principles* (p. 86, 1917 *edn.*) the case is described *to illustrate the principle* that in some instances " scientific selection of the workman counts for more than anything else," in *Shop Management* (p. 85, 1911 *edn.*) it is given *for the purpose of illustrating a totally different principle*, namely, that of " measuring a man's performance against a given task at frequent intervals."

It is true that selection is referred to in both accounts; but the statements concerning it are not identical in the two. In *The Principles*, the term " personal coefficient " is used and explained, and, though the phrase " reaction-time " does not occur, there is some excuse for those who have construed Taylor as meaning that a visual reaction-time test was

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* My own account of the case (*Lectures on Industrial Psychology*, 2nd *edn.*, pp. 112–116) is probably more misleading than this account of Taylor's, upon which chiefly it is based.

† I am indebted to Mr. Sandford E. Thompson, who was directly responsible for the selection of the inspectors, for important information concerning it. At the same time, Mr. Thompson probably would not admit that Taylor's account in *The Principles* is misleading, and should not be supposed to be in agreement with my contentions. He has been kind enough, however, to supply me with certain facts not obtainable from Taylor's accounts, and these confirm my conclusions drawn from a comparison of these accounts.

‡ These dates are taken from H. B. Drury's *Scientific Management* (*note* 2, p 101). I have at hand no means of verifying them; but a knowledge of the dates is unnecessary for a proper estimation of the facts.

made the basis of selection, as the following paragraphs (*ibid.* p. 89) show:—

> " In the Physiological departments of our universities experiments are regularly conducted to determine what is known as the " personal coefficient " of the man tested. This is done by suddenly bringing some object, the letter A or B for instance, within the range of vision of the subject, who, the instant he recognises the letter has to do some definite thing, such as to press a particular electric button. The time which elapses from the instant the letter comes in view until the subject presses the button is accurately recorded by a delicate scientific instrument.
>
> " The test shows conclusively that there is a great difference in the ' personal coefficient ' of different men. Some individuals are born with unusually quick powers of responsive action. With some the message is almost instantly transmitted from the eye to the brain, and the brain equally quickly responds by sending the proper message to the hand.
>
> " Men of this type are said to have a low ' personal coefficient,' while those of slow perception and slow action have a *high* ' personal coefficient.'
>
> " Mr. Thompson soon recognised that the quality most needed for bicycle-ball inspectors was a low ' personal coefficient.' Of course the ordinary qualities of endurance and industry were also called for."

All this definitely suggests that a visual reaction-time test was given. Whatever the selection test used, however, it led to the dismissal (or transference to other work) of " many of the most intelligent, hardest working, and most trustworthy girls " (p. 90).

When we come to the *Shop Management* account, we find no reference whatever to " personal coefficients." Selection is certainly mentioned; but the procedure adopted is not defined, and we are left to infer what it was from the fact that it led to the dismissal of those who " proved to be incorrigibly slow or careless " (p. 88). According to this account, the selection seems to have consisted *exclusively* in " weeding out of the lazy " and unpromising candidates, and the substitution of more ambitious " individuals " (p. 90). Thus, while in *The Principles* the important factor is the " personal coefficient " and moral and intellectual qualities are so unimportant that the possession of them by a girl with a *high* " personal coefficient " does not prevent her dismissal, in *Shop Management* the *moral* qualities are the *only qualities mentioned* in discussing fitness for the work.

Two questions thus arise:—

(1) Exactly what selection method was used?

(2) For what part of the increase in individual output was selection accountable?

(1) The selection method consisted in timing certain elements of the work with an ordinary stop-watch, and in engaging or retaining for the work such girls as were able to perform these elements with relative rapidity, *provided that they possessed at the same time certain moral qualities* (application and ambition, for instance). That the stop-watch was the instrument used for determining the " personal coefficients " may be inferred with some confidence from Taylor's usual methods of work, and has been confirmed by external evidence.* The elements timed were such as—

(*a*) pouring balls on to back of hand;

(*b*) picking off a number of defective balls with magnet;

(*c*) pouring balls into box.

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* For information on this point I am indebted to Mr. Thompson. It appears to be a common view in America that no one acquainted with the early stages of the efficiency movement there would have supposed Taylor to have meant that a reaction-time test in the strict sense was used. This

It is therefore inaccurate to suppose that selection was made by means of the laboratory reaction-time test.

(2) Even in the account given in *The Principles* (which was intended to illustrate the possibilities of *selection*), reference is made to other factors that helped to effect the increased output, such as a shorter working day and higher wages; but it is only in *Shop Management* that the importance of these other factors is adequately suggested. For the purpose of indicating how great their influence was, it will probably be sufficient to give a list of them (*vide* the *Shop Management* account). They were :—

(1) increased supervision of the work by means of systematically controlled over-inspection;

(2) introduction of task work, the task being determined by time-study;

(3) frequent appeals to ambition, which made use of a comparison between the standard task and the actual output at any time;

(4) preventing the girls from talking by seating them some distance apart;

(5) reduction of hours from ten and a half to eight and a half per day, and the giving of a half-holiday on Saturdays, and two days per month;

(6) introduction of two ten-minute rest pauses during the day;

(7) change from day-rate of wages to differential piece-rate, which allowed those making their tasks to double their former earnings, and penalised those who did not make their tasks.

It is difficult to understand how Taylor, acquainted with all these features of the "systematisation" of the bicycle-ball inspecting, could ever for a moment have supposed that the results were *chiefly* due to selection. It is surely unscientific and misleading to use so complex a case *to illustrate the principle* that scientific selection of workers sometimes counts for more than anything else. It would, indeed, have been a very difficult task for a man on the spot to decide how much was due to one factor and how much to another, even after the most careful investigation. It seems pretty clear that no such attempt was ever made, and, with such data as are obtainable, it does not seem possible to make it now.

It should, however, be noted that ten of the old girls were found suitable for the work when the selection standards were applied to them; apparently, their "personal coefficients," diligence, and ambition were satisfactory. These girls accomplished 142 per cent. more after the "systematisation" than before (*vide Shop Management*, p. 91). They were, of course, *selected* girls, just as much as if they had been newly engaged. Evidently, then, the "systematisation" features were such as would have increased the output of *selected* girls by 142 per cent. And the factors producing this result are regarded in *The Principles* as very secondary.

It is important that these facts should be realised, as only harm is likely to result by making claims for selection which those who have had much to do with factory work at once feel to be extravagant. The probable advantages of scientific selection are considerable enough to make them seem desirable even when stated without exaggeration.

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may be true; but Taylor's reference to the experiments in "the physiological departments of our universities" is still misleading, as his statements here could refer to nothing whatever except the strict reaction-time test. Further than this, in summing up Taylor describes the procedure followed as "the substitution of girls with a low personal coefficient for those whose personal coefficient was high" (*Principles*, p. 97). In view of his previous explanations of what is meant by a "personal coefficient," this statement is so misleading as to be simply false. It is noteworthy that Münsterberg considered a reaction-time test to have been used (*Psychology and Industrial Efficiency*, p. 54), and even uses the words—"excursion of an efficiency engineer into the psychological laboratory" (*ibid.*, p. 55), as descriptive of what happened.

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